INVESTIGATION ON DEVELOPMENT OF EARTH ROADS

By S. S. Steinberg, Highway Research Board, National Research Council, Washington, D. C.

(Presented at Fifth Annual Meeting, Highway Research Board of the National Research Council at Washington, D. C., Dec. 3 and 4, 1925.)

Highway engineers have long felt the need of a type of road surface that would serve for secondary or local traffic and yet be low in first cost and maintenance. Though considerable has been accomplished in the development of the higher type surfaces for use on main traffic roads comparatively little progress has been made in the methods for improving secondary or natural soil roads, which constitute about 85 per cent of the total road mileage in the United States. In their present unimproved condition the local roads cannot function properly as feeders to the main routes, thus depriving considerable areas and great numbers of individuals of the benefits of those portions of our highway transportation system already completed.

In view of the enormous mileage of local roads and the comparatively small amount of traffic upon them, it is evident that for many years to come it will be economically impossible to surface all these roads with the more costly types of pavements.

Realizing this fact, the state highway departments and the universities have conducted experiments for the purpose of stabilizing and protecting the surface of earth roads. These have included soil selection methods, bituminous treatments, chemical treatments, and veneer-macadam.

The objects of this investigation are to coordinate the efforts and data already available on the improvement of earth roads and to stimulate further research in order to find an inexpensive road surface to carry intermediate traffic.

It is recognized that no single answer to this problem would serve the entire country, but that due to differences in soil and climatic conditions the solutions will be matters affected by geography and geology. It is also felt that a proper solution may need to take into account the chemistry of the road itself, a field of research as yet untouched, but one which may help solve not only the earth road problem but also many of the subgrade difficulties encountered in the use of the more costly surfaces.

The writer's connection with this investigation has been a temporary one, and the study thus far has been preliminary and chiefly for the purpose of assembling and correlating all available information of completed, current and proposed research on earth road treatments. No field inspections have yet been made, but the material assembled will enable the investigator to study effectively in the field the experiments completed or under way in many sections of the country.

Thus far the following work has been done:

1. Statistical material has been collected for determining the mileage of and expenditure on earth roads in the states.
2. Through the kindness of the Chief Bibliographer of the Library of Congress, and with the aid of the U. S. Bureau of Public Roads, a bibliography on earth roads and earth road treatments has been prepared.
3. A search has been made in the Patent Office of all patents granted on earth road treatments of which about a hundred have been assembled.
4. Information has been gathered of research on earth roads now under way in various states and by universities.
5. Through the state contact men of the Highway Research Board information has been secured as to methods of earth road treatment now in use in the states.
6. By correspondence and conferences interest in the earth road problem has been aroused among highway engineers and researchers.
7. By radio talks and by articles in the press, the attention of the public has been called to the importance of the present investigation.

I desire to express to the state highway departments and to the universities my appreciation for their cooperation in the study thus far. Not only have they shown a readiness to supply all information they possess, but they have expressed a desire to be informed as to how they might contribute by research toward the success of this investigation. With such united effort the solution to this important problem cannot be far distant.

IS MUNICIPAL WATER SOFTENING PROFITABLE?

By Ross A. Thuma, Superintendent, St. Paul, Minn., Water Filtration Plant

(Editor's Note: The following matter is from a paper read before the 1925 meet-

ing of the Minnesota Section, American Water Works Association.)

The question of hard water as a municipal water supply as opposed to that of softened water has been under consideration at the Saint Paul Water Purification Plant for more than two years. We have investigated the problem of water softening from many different standpoints, such as health, plant operation, economy, utility, etc. The purification plant was operated as a softening plant during the month of January, 1925, for the purpose of determining whether it would operate as such. While the period of one month may be too short to form a definite conclusion, our experience was such that we feel confident that the plant would function as a softening plant. Our difficulties were, however, of a different nature namely, that of convincing the public that softening treatment was worth while. The two questions which seemed to be uppermost in the minds of the citizens were: first, will the softening treatment be in any way injurious to health; and, second, will there be sufficient savings to warrant the installation of the softening process? While the value of water softening may be considered from many angles, we will show that there is no probable danger to the health of the water consumer from the use of softened water, and that the returns on the investment from water softening are, indeed, generous. Furthermore, we will endeavor to show that water softening is a question of economy and utility, and not a question of health.

Water Softening in Relation to Health

If one will refer to Water Supply Paper No. 496, United States Geological Survey (by W. D. Collins) he will find the following data: The United States Geological Survey has divided the country into four sections on the basis of the water hardness.

The first division includes the section of the country which has water of a hardness of from 0 to 55 p.p.m. or the soft water area. This territory includes the Northwestern section of states, New York, the states bordering on the Atlantic and Gulf Coast to Texas, with the exception of Florida, and the states of Oregon and Washington. In this soft water section of the country there are more than 17,000,000 people using soft water.

The second division includes the section of the country which has water of a hardness of from 56 to 100 p.p.m. or the medium soft water area. This territory includes the second tier of states from the Atlantic coast and the states of Montana, Idaho and Nevada. More than 5,000,000 people in these states drink medium soft water.

The third division includes the section of the country which has water of a hardness of from 101 to 200 p.p.m., or medium hard water area. This territory includes the following states: California, Wyoming, Utah, Colorado, New Mexico, Texas, Arkansas, Missouri, Ohio, Michigan, Wisconsin, Minnesota and North Dakota. More than 11,000,000 people in this section drink medium hard water.

The fourth division includes the section of the country which has a water of a hardness of from 201 to 500 p.p.m., or hard water area. This territory includes the state of Arizona, Oklahoma, Kansas, Nebraska, South Dakota, Iowa, Illinois, Indiana, and Florida. More than 5,000,000 people drink hard water in this section of the country.

Type of Water has Little Effect on Health

There are then in the United States more than 23,000,000 people who drink water of 100 p.p.m. hardness with apparently no ill effects. Then there are more than 16,000,000 people who drink water of more than 100 p.p.m. hardness with no ill effects. We would, therefore, be forced to conclude that the hardness of the water exerts no noticeable physiological effect upon the water consumer.

Then again water softening removes two elements from the water, namely, calcium and magnesium. The body requires for its growth and development about fifteen of the chemical elements. If we must look to our food supply for thirteen of the fifteen chemical elements needed for the upbuilding of the body, why not include the other two in the food requirement? Without going into the detail of the matter, we believe that the average diet that will furnish the other elements will also furnish the necessary requirement of calcium and magnesium. In view of the above facts, we believe that it is obvious that water ought not to be used for the food elements it contains, but rather as drink.

Taste of Water Important from Consumers' Standpoint

The taste of water is one of the things which plays an important part in deciding the character of a water supply from the standpoint of the consumer. When one has accustomed himself to drinking water of a given hardness he will dislike the taste of water of a different hardness. A difference in hardness of 25 to 40 p.p.m.

is noticeable. In view of the difference in taste due to difference in hardness, it would seem that the water department would place itself at an advantage by serving water of uniform hardness. The St. Paul water supply varies in hardness from 135 to 225 p.p.m. during the year. By softening the supply to a given hardness, say of from 85 to 100 p.p.m., the objections from change in taste due to change in hardness would be eliminated.

Cost of Softening Water as Determined at St. Paul Plant

It is a comparatively easy matter to figure out the cost of softening a water of known hardness. The benefits to be derived from such work are on the other hand particularly difficult to calculate. However, from various estimates derived from the use of soft water, we believe it is well worth while. In this paper we will consider the cost from the viewpoint of increased cost in chemicals; our working force remains the same whether we soften the water or use aluminum sulphate.

The water during the month of January 1925, had a hardness of 180 p.p.m. We will base our estimates on the reduction of the hardness to 85 p.p.m. This would require a reduction in hardness of 95 p.p.m. In order to reduce the hardness to the figures given we used lime of 90 per cent available calcium oxide, at the rate of 137 p.p.m. and ferrous sulphate at the rate of 17 p.p.m.

We did not have facilities for recarbonating the softened water for eliminating caustic alkalinity. The caustic alkalinity averaged for the month 27 p.p.m. Recarbonation would be necessary in case softening was to be made a continuous process. When recarbonation is practiced there is no danger of after precipitation of lime on the sand grains, pipe lines, meters, and the alkalinity of the water is under control. We can regulate the reaction of the water within narrow limits to the convenience of the requirements. On the cost of recarbonation we will quote from the experience covering over a period of three years at the Defiance, Ohio, water plant.

For recarbonation of the softened water to eliminate caustic alkalinity on the average of 42 p.p.m. and leaving the water charged with two and one half p.p.m. free carbon dioxide as practiced at the Defiance plant. The carbon dioxide is generated from the burning of coke in a small furnace. They figured coke at $12.50 per ton for use in generating the carbon dioxide. The net cost was $1.30 per million gallons of water carbonated.

The permanent hardness of our water supply is too low to require the use of sodium carbonate.

Cost of Softening 1,000,000 Gallons

The cost of softening a million gallons as required at the St. Paul plant may then be tabulated as follows:

Cost per million gallons for lime—137 p.p.m. Rate of $12.00 per ton F. O. B. plant	$6.59
Cost per million gallons for ferrous sulphate—17 p.p.m., rate $18.40 per ton F. O. B. plant	1.32
Recarbonation as at the Defiance plant	1.30
Total cost of softening 1,000,000 gallons of water	9.21

If the cost of treating the same amount of water with aluminum sulphate is deducted from the total cost of softening we would then have the net cost of softening. The cost of treating 1,000,000 gallons of water at the rate of 34 p.p.m. and at the rate of $26.60 ton F. O. B. plant, $3.80. Deducting this amount from the cost of softening 1,000,000 gallons of water, we have a net cost of softening per million gal., $5.41.

The Value or Return from Water Softening.

The soap saved by the use of softened water is a direct measure of its value. Since the soap-consuming power of the water is one of the factors most easily calculated and verified, it will be given first consideration. If we refer to Whipple's formula for soap saved by softened water, we find that for a reduction of 95 p.p.m. hardness, we would decrease the soap requirement of the water equivalent to 21 pounds per thousand gallons. Equivalent to 21,000 pounds per million gallons of water used with soap. Obviously not all of the water softened would be used with soap. We believe, however, that an estimate of five per cent of the water softened would not be excessive. This would include water used for laundry, lavatory, dish washing, scrubbing, etc. Figuring soap at ten cents a pound, which is probably below the average cost, we may then calculate as follows:

21,000 pounds of soap at 10 cents per pound	$2,100
Five per cent of this amount used with soap	105

Our savings on the cost of soap to the community would be enough to justify the expense of softening the water. To this should be added, also, a utility factor; soft water being more usable than hard water.

The Saving of Fuel by Softening a Water Supply

A great deal has been written and said about the saving in fuel from the use of soft water for boiler purposes. On this point we have nothing definite. However, an estimate of this saving may be made. It has been estimated by various authors that a saving of at least five per cent may be made by the softening of boiler water supply. As a basis for comparison and cost estimate we will consider that five per cent of the coal used in the city of St. Paul might be saved by softening the water supply. There was used in the city during the year of 1923 about 1,550,000 tons of coal and coke for fuel purposes. If we estimate it at a cost of ten dollars per ton, we could then calculate that the loss on coal from the use of hard water would be:

75,000 tons of coal at $10 per ton $750,000
On the daily basis 2,050

During the year of 1923 the average amount of water used was about 20,500,000 per day or for each 1,000,000 gallons of water, or $100.

Other Reasons for Saving from Softening Water

Our experience at the St. Paul Purification Plant indicates that a larger amount of water could be filtered when the water is given the softening treatment than when treated with aluminum sulphate. For example, when the water was softened our filters filtered on the average 6,400,000 gallons of water for each filter washed, while during the year of 1924 the average amount of water filtered for each filter washed was 4,076,000 gallons.

In lake water where the algae are apt to be high during the winter months softening treatment has the advantage of precipating the algae and rendering them less troublesome.

In water high in organic matter, either in a highly dispersed condition or in solution, softening has the advantage of removing more of the organic material and thereby cutting down the chlorine requirement.

By softening and recarbonating the water supply it would be possible to keep the water very near the neutral point and thereby reduce corrosion to the minimum.

There would be less frequent shut down of boilers for repair, less loss from blow off water, less boiler up-keep, less labor and repair, less cleaning of scale, and less cost for boiler compound.

In conclusion I believe that I have shown that the softening of a municipal water supply, will in no way injure the health of the water consumers; that the problem of water softening is an economic one, and not a health problem; that the process of water softening is eminently worth while, and that it should have serious consideration wherever the hardness of the water is over 100 p.p.m.

DRIVE AGAINST "GOVERNMENT IN BUSINESS"

The present session of Congress will see an effort inaugurated by more than one hundred trade associations to halt appropriation of public funds for use by governmental bureaus in purely commercial activities. This will be the national phase of a campaign to be launched by a permanent coalition recently formed in Washington by the nation's industrial leaders to combat "government in business."

State, county and municipal authorities who "enter into competition with private initiative for the sake of political expediency or sheer extension of bureaucracy" will also feel effects of the campaign, according to leaders of the Conference on Government in Industry, as the coalition is to be known. Intrusions by these smaller units of government are designated by the business men as "even more vicious" than those of the federal body.

First plans for the movement to enforce the principle that the "functions of government are political and not economic" were laid at a meeting held recently by 175 industrial leaders representing all the major lines of commercial activity.

The conference voted to establish headquarters in Washington through which the following committee, which it elected, will act as the directing force for all existing organizations taking part in the movement:

Homer L. Ferguson, president, Newport News Shipbuilding and Drydock Company, Newport News, Virginia; F. Highland Burns, president, Maryland Casualty Company, Baltimore, Maryland; J. E. Edgerton, president Lebanon Woolen Mills, Lebanon, Tennessee; S. M. Williams, Vice president, Auto-Car Sales and Service

Company, Ardmore, Pennsylvania, and Gen. R. C. Marshall, Jr., general manager, Associated General Contractors of America, Washington, D. C.; Mr. F. J. Koster, president, The Koster Company, San Francisco, Cal.; W. O. Washburn, president American Hoist & Derrick Company, St. Paul, Minn.; Martin Insull, president Middle West Utilities Company, Chicago, Illinois; Elmer Bliss, President, Regal Shoe Company, Boston, Mass.; G. S. Brown, president, Alpha Portland Cement Company, Easton, Pennsylvania, and Harry Scullen, president, Scullon Steel Company, St. Louis, Missouri.

The conference adopted a report declaring that the proper functions of the government were political and not economic. It declared that industrial enterprises already in operation or contemplated by government, municipal, county state and Federal "are of such magnitude and diversity of character that they are seriously endangering numerous private industries." Continuing, the Conference's report said:

"Government enterprise pays no taxes. When government displaces private business, the loss in taxes as well as the excessive cost of operation is levied upon property and business which survives. The National Defense is best and most economically served by private business enterprises which may be converted to war purposes in case of emergency.

"Government enterprise almost invariably incurs a loss far exceeding any possible profit. These losses constitute an unjustifiable waste of public money. Costs of government are concealed from the public by neglect to employ a system of cost accounting which fully reveals the total expense.

"Government in business drives citizens out of legitimate occupation. It discourages business which is threatened. It squanders the money of the taxpayers, increasing their burdens. It is marked by extravagant delays, public inconvenience and loss. It deludes those engaged in agriculture, industry and commerce with estimates of cost in undertakings for which they must pay, piling up costs in excess of estimates under no responsibility or check.

"Government and industry must be protected against the assaults of those who would destroy both by confusing the functions of each. The door of opportunity must be kept open.

"We call upon every citizen to take stand squarely upon the proposition that the American Republic is founded upon the private ownership of property and maintained by the private enterprise of those engaged in gainful occupations."

The Conference formally asked that government, whether municipal, county, state or federal, abstain from business in which citizens "may properly and legitimately engage." Every group of those who conduct or serve industry was urged to adopt this policy "as affecting their particular vocations and to join in cooperation among the several groups to establish and maintain it."

The Conference outlined plans:

To disseminate among the people correct information as to the extent, cost and results of governmental enterprises.

To urge that in all government operations there be established a recognized and adequate system of cost accounting; and that all existing prohibitions against rewarding labor on merit and efficiency be abandoned.

To inform the people that government in business means the establishment of a socialistic state and the ultimate destruction of all individual opportunity.

To oppose every existing or proposed intrusion by government into the proper field of private enterprise.

The membership of the Conference was cited as being composed of the following three classes: trade association; business and professional organizations, and companies or individuals whose interests are or may be directly affected.

During the course of the conference, more than half the members of the conference indicated the penetrations which state, county, municipal and federal agencies have made into their fields of activity and outlined the tendency toward further intrusions.

William B. Ferguson, spokesman for the shipbuilding and ship repair industry and Edwin H. Duff, representing the American Steamship Owners' Association, addressed the conference today. Mr. Ferguson flayed the lack of uniformity of management in American navy yards, while Mr. Duff offered his organization's hearty support in getting the government out of the shipping business.

Mr. Ferguson gave concrete illustrations of private shipyards outbidding those of the federal government on construction and ship repair work. He said his criticisms of governmental competition in his field were based on a report

made by the Paymaster General of the Navy to Congress in which "fictitious figures" were used by the Navy department in estimating overhead charges.

Mr. Ferguson in his analyses of government costs in navy yards as compared with private shop yards declared that "It is from 20 to 50 per cent cheaper to do work in a private yard than in a government yard." He also gave specific instances where false economy was practiced by naval officials. Labor costs were higher to the government than to private shipyards, he declared.

The government, he continued, is compelled to change its executive yard personnel frequently and costs of clerical hire were above those of private yards, he declared.

He claimed that the "ever-changing of personnel" in each yard at frequent periods was a handicap to the government in securing quick and efficient service, whereas the American shipbuilder aims to maintain a permanent executive and mechanical force to keep its business on a larger capacity basis than at government yards.

He further said the government had no way to tell of losses and profits but it was his opinion that the losses would amount to countless millions over a period of years. He pointed out one specific instance where the overhead charges should have been placed at 150 per cent instead of 35 or 40 per cent as reported by the Navy Department.

Mr. Ferguson further criticized the government in that it has no responsibility to shoulder in the event "a particular job runs over its estimates", unless it be "the penalizing of its taxpayers."

In referring further to wages paid to government shipyard workers, Mr. Ferguson declared that the average hourly rate in government yards was 20 per cent more than in private yards.

Mr. J. E. Edgerton, who presided at today's sessions, before calling for adoption of reports, warned the business men of the dangers confronting the various channels of industrial enterprise. It was his opinion that the business man generally was neglecting his fundamental obligations of good citizenship and must be awakened to become more interested in political affairs of the country.

He pointed out that the Conference recognized its duty to cure the organic troubles within industry. He said that the evils of the government's encroachment upon business generally have multiplied over a period of years and which cannot be corrected in a few days. He asked that the members of the conference work in unity to abolish these evils by "endurance, sacrifice, hard work, and sustained interest."

The Resolutions Committee was headed by Mr. F. Highland Burns, while the Committee on Organization and Nominations was in the hands of Mr. George B. Walbridge, as chairman.

Assurances that the "Conference on Government in Industry" would have the full support of the organizations represented at the Conference were voted and adjournment was taken until the next call of the executive committee.

THE RAILROAD AND THE MOTOR BUS

By H. F. Fritch, President, Boston & Maine Transportation Co.

(Editor's Note: The following paper was presented on Nov. 14, 1925, before the Society of Automotive Engineers.)

Feeling that it should make every proper use of the motor vehicle, the Boston & Maine R. R. has organized an automotive auxiliary known as the Boston & Maine Transportation Co., a Massachusetts corporation. This company is carrying on certain motor truck activities in the nature of store door delivery and road haul, which, however, will not be discussed here.

Replacement of Train Service by Motor Bus

With respect to the use of the motor bus, it is the intention to use it to replace train service where it can perform the service more economically, as a supplement to rail service between trains, as a feeder to rail lines from new territory, as a feeder along main lines serving local stops, and as a touring service to care for pleasure travel which desires to go over the highways.

The first motor installation was in the fall of 1923 before the organization of the Transportation Co. A short branch line had been furnished with steam passenger service at a loss for a long time. This steam service was replaced by unit gas rail car service which reduced the loss materially but which was still carried on at a substantial loss. Later the unit car was replaced by a motor bus on the highway and the frequency of service materially increased. This service is still per-

formed at some loss because of the scanty patronage available, but of much less magnitude than heretofore.

Since last May the Transportation Co. has inaugurated a number of services to try out the application of the above-mentioned theories. Various installations will be mentioned, not for the purpose of describing particular localities and conditions in detail, but more for the purpose of calling attention to the essential features of the various types of operation and in so far as possible, in view of the short period of operation, to give some idea of the results.

There is a 12-mile steam railroad line from Portsmouth, N. H., to York Beach, Me., on which in the winter two steam trains were operated in each direction and in summer four trains. This operation has been unprofitable and at the beginning of the past summer season bus service was substituted with 12 trips in place of four steam trips, and more recently on the fall schedule four trips in place of the customary two steam trips. Not only did this route replace the steam service, but an extension of twelve miles was made along the shore with a tie-in on the other end with main line railroad service. This extension of service was in a territory not heretofore served by the steam road.

This service was very satisfactory to the community and produced a revenue much in excess of that from the former steam service. During the summer season the revenue was substantially in excess of the cost of the service. Whether or not this condition will apply on a full annual basis is yet to be determined by experience.

Bus Service in Competition with Steam Service

A bus installation was made on an inter-state run of 110 miles between Boston and Portland. This operation, in direct competition with the company's own steam train service, was established largely because there was competition also by three other bus lines. The railroad company's bus lines charged substantially the same as the railroad fare, while the others operated on a cut rate after the railroad bus line appeared. The secondary purpose of this operation was to get first hand information as to the desires of the traveling public and the effect of the bus on railroad travel. A large number of passengers have been carried, at times as many as four buses being required on one trip.

In order to get accurate information as to the reasons for passengers using such service, for a period the travelers were asked to fill out questionnaires. Replies showed that 87 per cent were traveling on pleasure and that 77 per cent of the total would have traveled by train if the bus service had not been available. This is truly an astonishing condition in view of the common claim that such service promotes a large volume of new business.

At the present time there is an entire absence of law regulating such inter-state operations. It is of vital importance that suitable law be enacted by Congress so that such operations may be limited to those which designated regulatory bodies shall find are required for public convenience and necessity.

Bus Supplements Train Service

Another operation is that in which buses have been used to amplify a steam train schedule. The Boston & Maine R. R. serves a wonderful summer resort territory with beaches, lakes and mountains in Massachusetts, Maine, New Hampshire and Vermont. Not so many years ago these places were reached only by train service, but with the advent of the automobile and improved roads the railroad traffic has suffered and it has been necessary to curtail the service. Such a curtailment, however, has a tendency to drive others to the use of the automobile and to detract from the popularity of the resort, both of which are to the disadvantage of the railroad. In order to meet this situation upon two lines in New Hampshire, one 29 miles in length and the other 42 miles, two bus trips in each direction were put on during the summer season in addition to the two steam trains. The bus trips made main line train connections in part formerly made by train trips. In addition they made available some train connections which have not been provided at all in recent years. This service met with much approval, but during the short period of operation this past summer was not entirely self-supporting. It seems probable that in another summer period with more advance information to the public financial results may be more satisfactory.

How Bus Service is Supervised

The supervision and maintenance of these operations is by an organization entirely separate from the railroad operating organization except that on some of the isolated routes railroad trainmasters and agents supervise the operation. However, as far as the public is concerned,

every effort has been made to adjust the bus service to function in harmony with the train service. Bus schedules are given a place in the general time table of the railroad and advertised generously about the railroad stations. Reservations for long distance bus routes are being handled in the railroad travel bureau. During the summer the Boston-Portland bus route was given the feature place in the railroad time table. At the same time some marked improvements have been made in train service on this route by adding new trains and reducing running time, which have also proved popular.

At the height of the summer season there were eight distinct services in operation covering 445 miles of route. For this service a fleet of 39 buses was used of two distinct types, 13 of the so-called street car type, and 12 of the parlor car type. In selecting the bus to be used the desirability of taking as nearly as possible a standard product was constantly in mind, believing that standardization is important if the production of motor buses is to be put upon an efficient basis.

Types of Buses Used

For the street car type of bus one of the standard four-cylinder chassis was used for 11 of the 14 and a standard light 6-cylinder chassis for 3 others. The bodies on these two chasses are practically identical except for length. The seating capacity of the body mounted on the light weight chassis is 21. The seating capacity on the four-cylinder chassis is 25 in the case of four buses and 29 in the case of ten. The general appearance and dimensions, except for length, are identical and the general type of construction is substantially the manufacturer's standard. These units are used in places where the average ride is relatively short and the interchange of passengers somewhat frequent.

In certain instances these buses are required to carry baggage, and part of the units have a door 32 ins. wide on each side at the rear and the rear bank of seats is replaced by five seats which may be tipped up against the back when not in use, affording a clear space for baggage. The floor is neatly bound with iron and the windows protected by bars, so that it is perfectly practical to carry trunks.

Considerations in Selection of Equipment

In selecting this equipment the characteristics of the service in which they were to be used were constantly in mind and the various dimensions of the unit were made consistent with these uses. The seats selected are substantially more comfortable than those provided ordinarily in the street car type of motor bus because of the feeling that a soft seat with adequate springs, is desirable, at least in all but the very shortest of city runs. The seat spacing is arranged to give adequate knee room and the width is generous. Aisle width is somewhat less than would probably be desirable in buses for strictly city service, but it is sufficient to allow passengers to move in and out without unreasonable crowding.

The inside finish of these units has been given a great deal of attention in order to make them attractive. In doing this no attempt has been made to equip them with unnecessary frills, but plain finish of good quality has been the practice with the feeling that in the long run such construction has the most appeal to the public.

For the exterior finish colors were selected which would be striking and attractive, not flashy, and at the same time practical from a maintenance point of view. The main body color is medium green with a cream belt rail. The roof is a light green. This color combination has the additional advantage of being quite visible at night.

Buses for Long Distance Runs

For the long distance work a standard chassis with 6-cylinder engine was selected. A standard body made by the same manufacturer was also taken. This unit is distinctly of the parlor car type with low head room, recognizing that no standing passengers would be carried. This body is ordinarily equipped for 25 or 29 passengers, depending upon whether or not inside baggage space is provided, but for this operation the seating capacity was cut down to 20 in order to provide the greatest practical seat comfort for every passenger. Instead of using the conventional arrangement of two seats on each side of the aisle two seats were placed on one side and one on the other. With this arrangement a double seat has a width of 38½ ins. inside the arms, and the single seat 19 ins. The seats are so arranged as to have no seat over the wheel house, the aim being to have every seat a comfortable one. Some baggage space is provided inside, but most of it is carried on the roof.

As in the case of the street car type, the inside finish was selected with the idea of having a plain, rich, and durable finish rather than a highly decorated finish which would have too great a ten-

dency to become shabby. Experience has shown that this policy was justified. Experience has also shown that the most satisfactory baggage space is inside the bus body rather than on the roof of it.

The outside finish of these buses is some what more decorative than the street car type which is in keeping with their character. Below the belt rail they are finished in a light green, and from the belt rail to the roof in cream. Our experience has shown that attractive outward appearance is of great value in attracting interest and business.

Predicts Railroads Will Make Large Use of Motor Bus

To summarize: The railroads in order to strengthen themselves and increase their ability to provide good main line service at the lowest possible cost must make use of the motor vehicle to supplant and replace rail service where the motor can perform the service more economically. Such a policy is to the advantage of both the community served and the railroad. The railroad as well as other bus operators should work conscientiously with the bus manufacturers to promote standardization of construction to their mutual benefit. Any improvements of the motor bus along the line of economy of maintenance and operation will assist the railroads in serving those of their communities which it is becoming increasingly difficult to serve by rail on account of their light traffic. I predict that the railroads will make large use of the motor bus.

ERA OF RAILROAD AND WATERWAY CO-OPERATION PREDICTED

Business growth of America will soon force intensive use of waterway transportation, Secretary of War Dwight F. Davis predicted in his address at the Mississippi Valley Association dinner in his honor held last November in St. Louis.

"Co-operation, not competition," was the Secretary's theme. After sketching the history of competition between the railroads and river transportation, he discussed the economic principles underlying the situation, and said:

"The man who talks of natural competition, and a finish fight, between river and rail, is as short-sighted as the Lancashire weavers, who wrecked the first machines for weaving cotton cloth. He sees a railroad between two cities carrying a certain amount of freight; he sees a river connecting them; he sees the possibility of the river taking the freight that now moves by rail. Then he thinks he sees the ruin of the railroad.

"Such a man does not see realities. He does not see, that, if the river can carry any particular kind of freight more cheaply than the railroad, the community will save money; that this money is new capital, which will produce more prosperity, and more production, and more goods to be transported by both the river, and the railroad. In other words, he does not understand the basic law of economics, that whatever increases the wealth, prosperity and efficiency of a community, benefits all the important elements of the community.

Traffic Efficiency Era

"The railroads have passed from the nineteenth century era of expansion to the twentieth century era of efficiency. They are not building new lines at the speed they did after the Civil War. Between 1910 and 1920 their total trackage increased only 5 per cent, but not all of this trackage was in use. They are seeking to do more with what they have, and in such items as miles per car per day, train miles per locomotive are making splendid progress. Of the unfavorable factors which they must combat, I take two at random; Unbalanced hauls and peak loads. Suppose a road has a long heavy eastbound movement, say of grain, and a light return movement. At a dead loss it must haul a great number of empty cars west. Suppose it could haul its grain east part of the way, and deliver it to a river carrier; suppose this means a saving to the shippers, and therefore more purchasing power; suppose they used this purchasing power, as they would to buy more merchandise, which would fill the cars that formerly went west empty. Would not the railroad be better off? Again, consider the peak load problem. We all know, in the past, a bumper crop of Northern wheat, or California fruit, or Florida truck, has taxed the railroads to their capacity and beyond. The crop is moved —eventually—after part of it has rotted, and farmers have had to borrow money to tide them through, and a blow has been dealt to prosperity, and to purchasing power, which is at once reflected in a smaller demand for general merchandise and therefore a smaller revenue for the railroads. Would not an intelligent rail executive be glad if some agency would

step in at such a moment and lift the burden of the peak movement from his overtaxed organization?

"There is not the remotest danger that the river carrier will drive the rail carrier from the field. Our most extensively developed river, the Monongahela, carries 25,000,000 tons a year, and its locks are worked to about two-thirds capacity; yet a prosperous railroad line runs on each bank. If either rail or river traffic were destroyed, there would be no benefit to the other, but only a serious loss to Pittsburg industry and the nation. Can anyone doubt that the same situation will exist when the commerce of the Mississippi the Missouri, the Ohio and their tributaries is similarly developed?

Roads to Retain Supremacy

"Successful river traffic is dependent on railroads. A railroad can go anywhere; it can run a spur to a factory door. But a boat can only go on the river. Except for a movement which begins and ends with in trucking distance of the river bank, part of the haul must be by rail. The other part for economy, should and will be by water, only when the water movement is, proportionally, long enough so that its cheapness in line-haul outweighs cost of trans-shipment. And besides this, there are the multitude of cases where, by ability to grant certain privileges, to give express service and to avoid rehandling, the railroad has natural advantages that neither can nor should be denied.

"Railroads are and will remain the backbone of inland transportation. Efficient waterway traffic cannot in most cases flourish without them. And we are coming to realize the converse, that efficient rail traffic depends on using to the limit the waterways. By reducing peak load, by balancing rail hauls, by taking the burden of low-grade traffic, by preventing car shortages, rivers can be and are becoming an essential element in the railroads fight for efficiency. And most important, the river can save money to the nation as a whole, and neither the railroads nor anyone else can avoid sharing in the resulting increased prosperity. Each should carry traffic for which, under the given conditions, it is economically best fitted; both carry jointly that for which joint carriage is most economical.

"Even if such co-operation were not otherwise sound economically, conditions would force its adoption. I have said that the present railroad trend is toward intensifying the traffic possibilities of existing lines rather than building new ones. But this process cannot continue indefinitely. When, in the coming generation, our internal commerce shall have increased 50 per cent or 100 per cent, it is evident that the present rail installations, no matter how efficiently operated could not handle it. Before long, in congested sections of the country, we must face the alternative either of intensive use of our waterways or of enormous investments in new railway lines. It is a question how far, and on what terms the railways could borrow the sums needed. But more important than this is the waste involved in spending billions of dollars to make a path over which commerce can move by rail, when nature has given us, in our great rivers, natural paths which can be made ready for commerce for a few millions dollars. The Mississippi, the Missouri, the Ohio and others are equivalent as possible commerce-carriers to scores of parallel rail lines. To neglect their possibilities is to throw away a gift of nature, and impose on the nation huge additional expenditures which will benefit no one.

Waterways Await Linking

"The provision of adequate channels for the future commerce of our waterways systems, notably those of the Mississippi Valley, is well advanced toward completion, thanks to the recent liberal policy of Congress and the activities of the Army engineers. What remains to be done is at once quite limited as to cost, and extremely urgent as to its effect on commerce. The incompleted gaps in the Mississippi system, which we are closing as rapidly as funds permit, have thus far retarded the growth of traffic far out of proportion of their actual mileage, for they are weak links in what should be a continuous chain. The Ohio, for example, is in terms of money about 85 per cent complete. But its commerce is not 85 per cent nor 25 per cent, of what it will become, for the unfinished part separates the canalized upper and middle stretches from the main Mississippi. It is like a railroad, mostly standard gauge, which has a narrow gauge connection with other railroad systems. The same remark applies in varying degree to the Mississippi, the Missouri and other rivers of the valley. Eliminate these narrow gauge gaps, and the system, for the first time in history is ready to take its rightful place in our national economy as a great, complete, co-operative transportation facility.

"But how can this co-operation be attained? The best efforts of the best minds of both rail and water executives are bent toward this accomplishment, and much has been obtained through the operation of the Inland Waterways Corporation, which has definitely proven that, given an equitable division of revenue to both rail and water carriers for a joint haul, the combined service will not only furnish the shipper a lower freight rate, but will afford a living revenue to each carrier."

Secretary Davis quoted the transportation act of 1920, in its provisions declaring the railroads entitled to a fair return, and setting forth a purpose to "foster and preserve in full vigor both rail and water transportation."

In carrying out this policy, he said, the Interstate Commerce Commission may order rail rates up or down. "It may order joint rail-and-water rates down, but not up. It may require the railroads to join in through rates with water lines even though the individual railroad may protest that such route deprives it of some particular haul it may otherwise receive. It may order the division of joint rail-and-water rates on bases which please neither the rail nor the water carrier.

"The commission may and does effectually deny railroads the right to enter into any form of unbridled competition with water carriers, which aims at or might conceivably cause the destruction of valuable water service. Here there would seem to be an adequate groundwork of law which should cause common carriers by water again to occupy the field as soon as the waterways are completed and capital is assured that its investments in this field will be adequately protected. All that the railroads need to be shown is that they will profit by co-operation, not suffer by competition, and they will co-operate. All that private capital needs to be shown is that such co-operation results in profitable investments in common carriers and capital will embark upon the enterprise.

"If we are ever, then, to succeed in our broad national policy of coordinating rail and water transportation for the present, adding motor and air transportation in the future, we must face the conditions as they exist, built broadly for the greatest good of the greatest number, utilize our great arterial waterways and their feeders, our coastal streams, and our canals, as they are completed, our lakes and our coastal waters, in co-operation with, and not opposition to our railways, which must always be the backbone of our unified transportation system that is to give us as nearly an ideal transportation system as the mind of thinking man can conceive. Our policy should be co-operation, not competition."

DOES PANAMA CANAL INJURE MIDDLE WEST?

That the Panama Canal, built by a substantial contribution from the taxes of the Middle West, is now working to the injury of this section, was the declaration of United States Senator Charles H. Deneen of Illinois, in an address on "The Lakes-to-the-Gulf of Mexico Deep Waterway Project" at the convention dinner of the Mississippi Valley Association in November, 1925.

Deneen, former Governor of Illinois, after narrating in detail the history of the waterways movement in his State and describing briefly the proposed Upper Mississippi River plan of waterways—the main stem from St. Paul to New Orleans, with stems in the Ohio River, to Pittsburg in the Tennessee to Nashville and the Missouri River to Kansas City—declared:

"The importance of the immediate improvement of the Mississippi River system is emphasized by the results at the Panama Canal. The Middle West favored the Panama Canal. It paid a great share of the expense of its construction. The Panama Canal is working an injury to the entire Middle West in the way of cheap freight costs from the Atlantic seaboard to the Pacific coast cities.

Figures to Prove It

"The rate by rail on first-class freight is $5.06 per hundred pounds from Chicago to San Francisco. The all-rail freight from New York to San Francisco is $5.55 per hundred pounds; the water rate from New York to San Francisco is $2.42½ per hundred pounds. This is a striking illustration of the advantage of waterway transportation and a striking proof of the necessity for providing such transportation for the Middle West.

"The Middle West is entitled to an outlet to the Panama Canal. The Panama Canal was meant to serve the country and the world, and its full benefits should be extended as far as possible to all parts of the country. At present, its chief benefit is enjoyed by the Eastern shippers to the Pacific coast at the expense of the Middle West.

"May I add as another illustration that copper is shipped from Butte, Mont., to Seattle, and then via the Panama Canal to New York, for $10.50 a ton less than it would cost by rail from Butte to New York? A heavy burden is placed upon the farm products, mining products, manufactured products and all imports and exports to the Middle West by the lack of waterways. This is an unnecessary and an unjust burden, and should be lifted."

Illinois Contribution

Deneen stated that, with the completion of present projects the State and the City of Chicago, will have expended over $120,000,000 on a channel leading to the Mississippi River 103½ miles long, 40 miles by the Sanitary District of Chicago and 63½ miles by the State.

"This is the contribution by the State of Illinois and its agencies," he said, "to the waterway from the Lakes to the Gulf of Mexico. Illinois asks only that the Federal Government care for the channel of the lower river from Utica, the terminus of the State Canal to Grafton, 228 miles away and of which the Federal Government has always had jurisdiction. The estimated cost to the Federal Government for this channel is less tran $5,000,000."

COMPREHENSIVE INLAND WATERWAY PLAN

(Editor's Note: The following is from an address by Maj. Gen. Harry Taylor, Chief of the U. S. Army Engineers, at a meeting of the Mississippi Valley Association at St. Louis, Mo., in November, 1925.)

"We are not badly off for a comprehensive plan. With 1,000 miles of the Ohio, 2,000 miles of the Mississippi, 450 miles of the Missouri, and 400 of the intracoastal canal from New Orleans to Galveston Bay, we have nearly 4000 miles in a plan for a trunk system—the backbone of the waterways of the United States. This main line will have many feeders, such as the Illinois and the Monongahela, which is one of the most intensively used rivers in the world.

"This entire system, with sufficient funds, can be completed within a comparatively few years. It will form the main line for any systems that may be added to it in the future.

Must Have Traffic

"I pointed out at your convention last year that two steel rails stretching across the continent were not of much value without traffic. In the same way, a four, six, ten, twenty or forty-foot channel, if not used, is of no benefit. And I pointed out also that you cannot now put any old boat on the river, land it any old place, and keep account of its freight by notches on a stick. Methods of river operation must compare with methods of railway operation.

"Last July I was surprised to learn that a barge line on the Upper Mississippi was not going up to St. Paul, but stopping below, not because the channel prevented, but because it could not get the freight. In September, however, I went back there and found that some of the business men had realized that it was time to do something more than talk about the river.

"I hope that movement continues. But now I hear talk of putting two lines on the upper river, with competition between them. The need here certainly is co-operation and not competition. If there is not enough traffic for one line, surely there is not enough for two. I do not want to butt in on any family row, but I must urge that, somehow, one line be agreed upon now, and that later, if the traffic becomes too much for it there may be two lines.

Use of Rhine River Cited

"A chart in the adjoining room shows that only 39 miles of the channel between St. Louis and St. Paul is shallow at 4½ feet. The remainder is 6 ft. deep. The chart bears an inscription that the Rhine, with only a 4½-ft. channel, carries millions of tons of commerce. Is that not giving a strong argument to the enemies of waterways? Here, with a channel of 4½ ft. or better, there is no business on the river; therefore, they will ask, 'Why do you need the rivers?' "

ILLINOIS HIGHWAY PROGRESS

Address by Gov. Len Small at 1926 Meeting American Road Builders' Association

We of Illinois have taken a great interest in the development of roads. For almost a century, the State of Illinois struggled along under the handicap of mud roads which were impassable during a large part of the year. The development of our citizenship, our schools, and our commerce was restricted by the stupefying and depressing obstacle of bad roads.

Prior to 1918, no comprehensive State Highway program had been developed. In 1918, our people by a referendum vote

adopted the $60,000,000 bond issue law which set up a system of State highways whose construction was to be financed by the proceeds of the $60,000,000 bond issue and surplus motor fees. Under this plan, the necessity of direct taxation for the retirement of the principal and interest on bonds or for the maintenance of our highways was eliminated, and all highway construction and maintenance have been financed without one cent of direct taxation.

Although this law was adopted in 1918, progress in the building of our State highway system was comparatively slow. The unusual economic conditions which followed the war with attendant embargoes upon materials, labor shortages, and inflated prices delayed the construction program.

When I became Governor of Illinois in January, 1921, one of the planks of my platform was that I would push the road construction program of our state with the greatest possible dispatch. I also realized that there was an inflation in the prices of highways and set about the unpopular task of eliminating this inflation and securing our State highways at fair and equitable prices. As a result of this campaign in which my official actions were most severely criticized, the price of the average 18-ft. concrete paved road with average conditions of grading and bridges was reduced from approximately $40,000 to $45,000 per mile to under $30,000 per mile and since that time our work has been kept within that limit. I believe that the entire highway industry agrees now that this course was entirely wise and justified by economic conditions. It is true that where we encounter unusually large bridges or topographic conditions which call for very heavy grading, the $30,000 per mile limitation does not apply.

We have enjoyed the distinction of establishing repeatedly world's records for the amount of durable hard surfaced roads completed by any State in a one year period. Our program reached its climax in 1924 when 1,230 miles of pavement were completed. During the past five years we have built 4,365 miles of road, and it is interesting to note that 78½ per cent of all the paved roads in Illinois lying outside of cities and villages have been completed during the past five years.

I have felt it my duty to stand behind our Highway Department in carrying out this road building in accordance with the most advanced engineering standards. Our highways have been located so as to bring out real economy of operation and construction and to provide maximum safety. Grade crossings have been eliminated by relocations or by grade separations wherever feasible.

I have felt it my duty to encourage engineering research, and I believe that by carrying out the Bates test road, which is well known to all of you, our State has contributed materially to the knowledge of road building of this country.

I have stood squarely behind our Highway officials in demanding that this highway work of our State be conducted on strictly business principles in which the lowest responsible bidder was awarded the work and all parties received an absolutely square deal, and at the same time the people of Illinois received a dollar's worth of value for every dollar expended.

Sometime ago I foresaw that the $60,000,000 bond issue funds would be exhausted and that our State road program could not be brought to a proper degree of completion without further financing. Accordingly I recommended to the General Assembly in 1923 the passage of a law permitting the people to vote on the proposition of another bond issue of $100,000,000 for the purpose of completing our original 4,800 mile system and enlarging it. This measure was passed by the General Assembly and was adopted by the people of Illinois by an overwhelming majority at the general election in November 1924.

We are now letting the few remaining contracts required for completing the $60,000,000 bond issue system, and during this year we hope and fully expect to start work on the new roads, and every effort will be made to complete at least 1,000 miles of durable, hard surfaced pavements during the year 1926. Within the next three or four years we expect to have completed with a durable hard surface not less than 18 feet in width a system of at least 8,000 miles of State trunk highways.

It may be said that roads have been my hobby. I have devoted every energy within my power as Governor of this State to advance the cause of good roads. Our entire economic life has been revolutionized by the paved roads already completed. With the completion of our proposed system, Illinois will undoubtedly be one of the best paved states in the Union.

KEEPING CONSTRUCTION COST RECORDS

By W. R. Smith, President Lane Construction Co., Meriden, Conn.

(Paper read at 1926 meeting of American Road Builders' Association.)

In the prosecution of highway work there are three dominant factors—the Lord, the engineer, and the contractor, I think these factors have been mentioned in the order of their importance.

The first factor, fortunately, is beyond human control. Rain and snow, heat and cold, are furnished for the best interests of all, but there are times when the elements seem to be handled in a very haphazard way.

The second factor in progress—the engineer—is the dominating human factor. He designs the project, lets the work, dictates the construction, accepts the job when his ideas are exhausted, and settles with the contractor, mostly on his own terms.

Trouble in progress often starts in the award of work because of the more or less general practice of awarding to the low bidder. If the public knew what that practice has cost this country, a cry would rise from coast to coast. Laws should be changed and authority given the awarding body or engineer to use discretion in award. The awarding body today deserves the confidence of the public and should be allowed to do business along business lines. The idea that engineers are grafters and contractors crooks is not true. We are doing business in seven Eastern states and all engineers or awarding bodies with whom we do business are, and have been for years, absolutely above the thought of any easy money for themselves or the contractor. Highway contractors may not be saints but the thieves are few. The award should go to the lowest satisfactory bidder. A man's record should count for more than it does. It is not always the man who has the best banking connection; he often fails in his organization. It is the honest man, the man in responsible financial condition, with a knowledge of the work which he undertakes, and who can show progress, to whom the work should be awarded.

I would like to call the attention of the Engineering Departments at this time to a few points over which they have absolute control and which are often the cause of delay to work. Sometimes a department, in its haste to get out work for bids, will submit work that is really inaccessible. We have had frequent occasions where it was impossible to get at certain parts of the job due to the fact that right of way on new location had not been acquired or that release of land for easements or drainage privileges were not to be had. We have also had instances where awards have been temporarily held up for lack of financing. Such things as these seriously inferfere with progress and are not only exasperating to the contractor, but expensive.

The inefficient and ignorant inspector, I feel sure in saying, is the contractor's biggest annoyance. The trouble is absolutely due to states and municipalities not forming engineering organizations adequate for work involved. A good contractor realizes that his organization can only be held by being paid in reason. One capable engineer, receiving adequate compensation, with one reasonable assistant, is worth more than the engineering mobs, often made up of kids and incompetents, that are seen on many jobs. One of our superintendents said that, as he figured it out, the state felt that they must support certain men and, rather than send them to the institutions for feeble-minded turned them loose on the contractor for fresh air and any suggestions he might make.

To the great number of competnt inspecting engineers is extended a most sincere appreciation of their worth. A good, by that I do not mean an easy, inspector is a job's great asset.

As a contractor, I have not the least patience with states or municipalities attempting to force speed on work by suggesting a penalty for lack of completion within a specified time unless they offer a bonus to the contractor for an early date of completion. The idea is wrong in theory and does not work out in practice.

One of the most annoying things in connection with work is that not sufficient information is given the contractor as to what will be required of him before his work is accepted. Often times, due to this lack of information the contractor transfers men who should be held, moves plant before it should be released, and makes his plans allocating superintendent weeks before it can be accomplished. This delay in work is largely due to the ideas of the inspector not being given the contractor. In many cases, the contractor has the ideas of the inspector in regard to completion; then the Assistant Division Engineer will come on the work with new thoughts; he is prob-

ably followed by the Division Engineer who may or may not agree; and lastly the Chief Engineer in charge of construction appears with his demands. There is an argument between the engineering force and the contractor as to whether he has or has not been told to do certain things. This last season, for the first time in our history, we met, to my mind, an ideal engineering situation. After the pavement was completed on a contract and while we were working on shoulders and incidental work an engineer appeared and went over the contract carefully with his inspector and our superintendent. The next day our superintendent received a letter stating that when such and such things were done the contract was accepted, the inspector on the job receiving a copy. In this particular instance, there were 35 things mentioned like lowering this ditch, removing a rock at Station ——, opening entrance to culver at Station ——, cutting back slope between Stations —— and —— removing stump, Station ——, cutting tree, Station ——, As soon as the superintendent received this list, he was absolutely in position to plan relieving plant and so organize as to quickly finish the work with the least possible expense and delay.

The third factor in highway construction is the contractor, and three things he must have—men, plant, and money. The ability to execute is the big factor and all the plant a machinery man can sell you is helpless without human assistance. It is organization that makes execution possible and organization is the great big factor in progress and success. Perfection of organization is a matter of growth. The men in our corporation are the survivors of many contract battles through a long period of years.

While handling several contracts at a time, we find a great help in progress lies in our ability to continually transfer men and plant from one job to another. Somewhere we generally have the engineer, or foreman, or machine required. It is easier to make progress on a lot of work than a little. I do not mean to decry the man who is working one contract. He may be the big operator of the future.

We are using a form for a daily Progress Report. This report is made up by cost clerk on the work in triplicate and signed by the Superintendent, who keeps one copy, sending one form to home office and one to Division Engineer. These reports carry a good deal of really valuable information but perhaps are not the assistance in progress you would expect.

Prosecuting the work and keeping intelligent costs are two things that should keep in step but often march away from each other. It is much easier to carry on work than to get intelligent costs, but the knowledge of the detail of costs is absolutely necessary to prosecute work in reason. The speed at which work should move lies somewhere between Made Haste and Slovenly Delay. It is only in a special instance that the progress of work should not follow the way of least cost consistent with satisfactory results.

Regarding intelligent costs—The human element has destroyed our hope of keeping costs exact but I would insist they are intelligent. After an experience of 35 years, I offer to you our first conception of cost method, with only minor changes from time to time.

When a contract is awarded, we give it name and number which are entered in one of our cost sheets and inserted in a loose leaf cost book.

All bills against a particular contract, as fast as they are properly approved and classified, are entered on the cost sheet at home office. The first column shown on the sheet is for date of invoice; the second, for name of the payee; the third, for quantity, wherever occurring, like tons of stone, gallons of asphalt, barrels of cement, feet of pipe. The quantities showing in quantity column are used in securing unit costs during progress of work and the checking of final estimate. The fourth column carries the total invoice. Then follow columns headed to cover differt items of cost desired, the sum of the classified items, of course, balancing the total, and once a month the cost sheet is balanced with the ledger.

A classification sheet, bearing the same cost headings as cost book, must accompany all payrolls from the field to main office. The classified daily cost balances with payroll. The total classified payroll is entered on cost book—same as invoices.

On completion of the contract, totals are brought to the bottom of the cost sheet; unit costs are worked out; unit receipts as shown against the cost; the total profit or loss of the job, and the percentage of profit or loss are computed. Everything of cost that can be shown against any one job is on this sheet. The cost sheet does not carry insurance, taxes, general repairs, depreciation, or salaries other than that of men detailed to a particular job.

This overhead is worked into a percentage on business done.

Depreciation as an item of cost does not receive the consideration it deserves. We make annually all the depreciation the Government will allow, but it is rarely we can sell used plant at its book value. Actual depreciation will put a fine nick in any contractor's profits and it is too often overlooked or greatly underestimated. Dead plant is not of any more value above ground than below; in fact, we burned and buried considerable this year.

Our field timekeepers or cost clerks, from their classification of payroll, have the information to give the superintendent field costs daily or as often as he may require. Our division engineers are given detailed costs once a month of work under their charge, and work up their own unit costs when desired. Our General Manager is given the total cost of each contract every week. When estimates are received, he places the amount of the estimate against the cost of the nearest corresponding date. At the end of the year all costs are carefully tabulated and then used as an element in future bidding.

Thus, in a general way, it is possible to tell continuously whether you are going or coming and put the best thought of your organization on the condition where it is most needed.

RECENT DEVELOPMENTS IN CONCRETE PAVING PRACTICE

By H. E. Surman, Engineer of Design, Illinois Division of Highways, Springfield, Ill.

(The following paper was read at the 1926 meeting of the American Road Builders' Association.)

The highway rolling stock of the United States has increased in such enormous proportions that it is a certainty that the owners of this stock will continue to demand the construction of highways at a rapid pace for some years to come. It is therefore up to the engineer continually to be on the alert to evolve new and better methods which will lead to better highways. The people are demanding more and more that the modern highway be safe, smooth, and well marked. They are not interested so much in the engineering details of this accomplishment as they are in the results obtained. It is the object of this paper to discuss in a brief way some of the more recent developments that are responsible for the present high standard in concrete paving practice.

One of the most important developments is the improvement in highway alignment. While a few years ago most of the states were satisfied to adhere quite closely to existing highways, relocations have become the order of the day, and we no longer hesitate in opening up entirely new rights of way for the purpose of saving distance between important centers, cutting down construction, operating, and maintenance costs, and avoiding grade crossings with railroads. Where a few years ago right angled turns were rounded by means of a 100 to 200 ft. radius curve and practically no superelevation was used, today the modern highway is built with a minimum 500 ft. radius curve for right angled turns with correspondingly longer curves for smaller angles, and adequate superelevation provided for all curves up to five or six thousand foot radius. The essential thing is to provide an alignment that will permit traffic to move at the legal speed limit with reasonable safety.

Earth shoulders are now built of sufficient width to permit a vehicle to park along the side of the pavement without interfering in any way with the traffic. This is a very essential feature of road design and construction and is an item which is not considered seriously enough by many of the states. The minimum shoulder width for country districts should be 6 ft., and near large centers of population, it should be 8 ft.

The development of the shallow side ditch, wherever practical is an important safety feature. The practice in Illinois is to construct a 4 to 1 slope from the edge of the shoulder to the bottom of the ditch, with the ditch only 12 ins. below the shoulder elevation. This practice could not, of course, be carried out in cases where deep ditches are required for larger quantities of water. This might also prove detrimental in some of the northern states because of the snow removal problem but wherever it can be applied without detriment to the drainage of the road, it will certainly help promote the safety of the highway.

One of the most outstanding and far reaching developments in concrete paving design is the standard cross section developed from the Bates Road Tests, conducted by the Illinois Highway Department during the years 1920 to 1923, inclusive. The main features of this design are the thickened edge with longitudinal steel bars near each outer edge, and a

longitudinal dividing plane in the center of the pavement with transverse dowel bars. More than thirty of the states are now either using this design or some modification of it. A more recent development of this design is the application of a heavier or thicker pavement near large centers of population. The Illinois practice is to use a 6 in. central thickness with a 9 in. edge thickness for traffic near small cities and rural districts, and a 7 in. central thickness and a corresponding increase in edge design for traffic near large centers of population. Pavements near the larger centers also are built to a width of 20 ft. for the initial construction unit, whereas the down-state pavements for the more rural districts are mainly 18 ft. in width. The edge design for the 7 in. center thickness pavement is computed to give a corresponding increase in strength as compared to the edge design used with the 6 in. center thickness pavement. This heavier type of design is not used for the purpose of permitting heavier loads to travel the highway, but as a safety guard for the fatigue in the concrete due to a greater frequency of maximum loads. Approximately 3,000 miles of concrete pavements have been built in Illinois on the basis of the thickened edge and longitudinal center joint design.

One of the most recent developments in highway design is the so-called superhighway where eight or more traffic lanes are provided for on the same right of way. This would seem to be the proper solution of the congestion problem in cases where parallel routes designed to relieve such congestion are already improved. To make the plan successful, however, it is necessary that adequate provision be made to take care of traffic all the way to the heart of the metropolitan area which produces the major portion of the traffic, and unless this is done, the object of the super-highway will be defeated.

Another important development which is just in its infancy is the matter of widening and strengthening existing pavement. This is the natural outgrowth of traffic increases on the more important routes, and the years to come undoubtedly will witness the widening of many miles of pavement that are no longer of adequate width to care for the traffic which comes upon them.

The public is continually demanding smoother pavements and too much emphasis cannot be placed on this important feature of concrete paving practice, because the quality of the pavement is often judged by the smoothness of its surface. The method described in specifications for obtaining smoothness varies considerably among the different states. In Illinois very good results have been obtained by the use of the compacting or finishing machine, belts, 10 ft. straightedge and long-handled float. The use of the long handled float and 10 ft. straightedge to remove the surplus water and laitance from the surface of the pavement have been largely instrumental in eliminating the scaling action that was so common in concrete road construction up to a year ago. Diligent application of the above mechanical equipment and tools has eliminated almost entirely the scaling action on the surface of concrete pavements placed in Illinois during the past year. The surface is checked for smoothness with a 10 ft. straight-edge both before and after the concrete takes its initial set, and all variations exceeding ¼ in. are at once eliminated.

A very good method for testing smoothness after the concrete has attained its initial set is by means of a machine known as the profilometer. This is a very simple machine constructed preferably of a number of rubber tired bicycle wheels with a device for recording the contour of the pavement as the machine moves over the surface. A number of different profilometers have been constructed by the Illinois Highway Department and tests were made of the various machines to determine their efficiency. Profilometers having 32, 16 and 8 wheels, respectively, were constructed, and assuming the 32 wheel machine to be 100 per cent efficient, it was found that the 16 wheel machine had an efficiency of 99:5 per cent and the 8 wheel machine, an efficiency of 97 per cent, or in other words, the 8 wheel machine recorded 97 per cent of the high or low spots that were recorded by the 32 wheel machine. It appears therefore that the 8 wheel machine is accurate enough for all practical purposes, and has the advantage of being easier to handle in the field. The profilometer, besides being a good detector of rough spots in the pavement, is a valuable machine in that it furnished an accurate graph of the surface of the pavement which can be used in future investigational work.

The question of obtaining the specified thickness for the concrete pavement is one of prime importance, but it is only very recently that engineers have taken

the proper precautions to insure that the thickness specified is actually obtained in the finished work. The strength of the pavement slab varies as the square of the thickness, and if the pavement is constructed only 5 ins. thick, where 6 ins. is specified, the resultant pavement is only about five-sevenths as strong as the design called for. In order to insure obtaining the thickness specified, the practice in Illinois is to require the use of a heavy subgrade templet which is mounted on rollers and placed on the side forms between the mixer and the concrete. Thus the subgrade is checked after the mixer has traveled over the same, and immediately before the concrete is placed. In addition to this, the resident engineer is required to take not less than three cross sectional readings on the subgrade each day and again on the finished pavement just after it has taken the final set. A final check consists of drilling cores and determining the actual thickness. Every effort is made to help the contractor to secure the minimum thickness specified as the work progresses, and it might be stated that since this method has been in practice, there have been exceptionally few cases of shortage in thickness.

Important considerations involving the quantity and quality of the resulting concrete are: checking daily the amount of cement used, and number of batches of concrete required per unit of length study of yield of concrete by suitable field determinations; automatic methods of measurement to secure uniformity of batches; automatic locking and timing devices to secure uniform mix; automatic water control to secure uniform consistency; and a tendency toward standardization of concreate mixers.

Another important development is the use of calcium chloride as a curing agent. This probably has been used in Illinois more than in any other state, not less that 2,000 miles of concrete paving having been cured by this method. Calcium chloride is applied in flaked or granulated form and spread uniformly over the surface of the pavement by squeeges or suitable mechanical device at a rate of about 2½ lbs. per sq. yd. of pavement. The main advantages over other curing agents are the saving of labor and the fact that concrete so cured attains a greater strength in its early stages.

The use of aluminate cement for paving short gaps and particularly for patches in maintenance work is becoming more popular. This enables the pavement to be opened within 24 hours after the concrete is placed and while the cost in small quantities is about four times that of Portland cement, it is justified from the standpoint of better service given the travelling public and the avoidance of lengthy detours.

One of the most important recent developments and one which adds greatly to the safety of the highway is the use of the traffic line. This was the outgrowth of the longitudinal center joint design for concrete pavements, although it is now used with equal success on other types of pavements. The center traffic line is now in use by most of the states and in the writer's opinion, has done more to avoid accidents on highways than any other one factor.

What might be mentioned as essential in concrete paving practice is the care being taken by the states to analyze the contractor's ability both financially and as to performance of work before awarding a contract. This involves the study of financial statements, the past performance of the contractor, equipment for performance of the work, and the contractor's detailed plan and schedule for handling the work.

During the past two years the transverse test for determining the strength of concrete has gained favor rapidly. This gives less variation in results than compressive tests on cores drilled from concrete pavements and has the added advantage of more nearly resembling the stress in concrete under actual traffic. Tests were made on 200 test beams, each 6x8x30 ins., enough concrete being made in one batch to cast two beams at one time. Both transverse and compressive tests were made on each specimen. By means of the cantilever testing apparatus, two transverse tests were made on each beam. From each of the three remaining sections of each broken specimen cores were drilled by a calyx drill so that by this method two flexual and three compressive stresses were recorded for each specimen. Tests were made at 14, 28 and 90-day ages. The results show that the average difference in the compressive tests amounted to 72 per cent, while the average difference in the transverse tests was only 3.7 per cent. Additional investigations should be made on this subject before reaching a definite conclusion.

It would not be fair to close a discussion on this subject without referring to highway research. Great forward strides

are being made in this phase of highway work and while much has been determined during the past few years, there are still important problems before us. Such questions as stresses set up in the pavement slab under different temperature and weather conditions and the behavior of different sub-soils have by no means been definitely solved. There are many other important questions regarding paving design and construction which will require the diligent efforts of all research agencies for some years to come. It is a very interesting and fruitful field and one which really has no ending.

HOW TO STOP CEMENT OVERRUN IN PAVEMENT CONSTRUCTION

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(Paper read at meeting of American Road Builders' Association at Chicago on Jan. 13, 1926.)

The title assigned to this paper may be somewhat misleading. We are all interested in the underrun of cement as well as the overrun; and furthermore the quantity of cement used on the job is so closely dependent on the aggregate and the construction practices that we must direct our attention to the latter rather than to the discussion of cement as a material.

We have overstressed the use of the word cement in connection with overrun and underrun. The use of the word has been so general that it has clouded the issue. Most contractors and engineers have lost sight of the fact, or have not realized, that simply because they are controlling the variation in cement, safely between certain limits as set out in a specification, does not mean the stopping of losses in other materials used; and that usually through a lack of knowledge, or a too earnest effort toward the controlling of the cement content by the inspector or contractor's organization during construction, the result is a loss through excessive or insufficient use of aggregate, both in quality and quantity of concrete produced.

Contractors have not been awake to the importance, to them, of the subject of overrun and underrun of materials in concrete. Continued losses, however, should cause us to open our eyes and endeavor to help relieve the situation. Those who have investigated the conditions and causes underlying the proposition have come to the realization that it is practically impossible to prevent overrun and underrun of aggregates, including cement, working under the conditions and requirements of the average specification as written today.

In figuring overrun and underrun of materials the theoretical quantity of each kind necessary must govern. It is the exception to the rule when any allowance is made in specifications to take care of losses, except in some cases a variation in cement. Contractors are prone to leave out of their estimate of quantities and provision for additional materials, over and above the theoretical amount, in spite of a positive knowledge that an extra allowance is necessary to prevent a loss in construction.

While this is true, from the viewpoint of the contractor who has benefited by his experience in construction, there are two bases on which to figure overrun or underrun in a job: The theoretical quantity from the engineer's side, and that of actual practice from the contractor's side.

What may be overrun to the engineer might be a figured loss by the contractor. A peculiar situation arises, particularly on jobs where cement is furnished by the contractor, and where the attention is directed more to prevent underrun without considering overrun of cement.

Much could be said about who is responsible for the conditions that exist and under which we work; but a great part of it is clearly the fault of the contractor. We can help our case by obtaining the the information necessary to prove it. We should do so at once and strive to correct it; for what will tend to straighten out our trouble, will, at the same time, result in a saving of materials, cement included, at no loss in quality of product, and establish a real and actual basis of figuring overrun and underrun. For discussion we will divide the factors entering into overrun and underrun of materials, cement included, under two main headings:

First, The Specifications. Second, The Methods and Equipment Used in Construction. These two divisions are practically of equal importance, and inseparable. Faults in either one will destroy to a greater or less degree the results desired, in proportion to the seriousness of the fault.

Specifications

However, since specifications are written before construction, they are given

first place. Contractors,at best, are more or less agents of the engineer in carrying out his ideas as set forth. Therefore, it is well to state at this time that prevention of overrun or underrun of materials, instead of being helped out by the average specification, is almost guaranteed to occur by their requirements.

In fact a contractor is trying to do an impossible thing when he contracts to meet a rigid specification for neat depth and quality, and, at the same time, confine himself to a definite material content, cement included. This cannot be accomplished in a practical way if the specifications which regulate the mix and methods of construction are to be complied with.

In this connection, it is evidence of an uncertainty or lack of definiteness when we find that Highway Specifications, which allow practically no variation in finished thickness of slab, do permit a variation from the stated cement factor ranging from 2 to 7½ per cent, and no allowance for increased yardage of sand and coarse aggregate.

This indicates clearly that there is need for a definite and equitable basis for estimating the correct quantities of materials for the job.

Engineers, in their specifications, should recognize the necessity and importance of safeguarding the contractor against overrun of materials as zealously as they guard against underruns; not by consent to laxity of skill or method by the contractor, but by removal of the uncertainties from their requirements.

Specification Vagaries

For example, when a specification sets out a 1-2-3½ mix, just what do they mean? Do they mean 2 cu. ft. of wet sand or do they mean 2 c. ft. of dry sand? Does 3½ cu. ft. mean 3½ cu. ft. of coarse aggregate with 30 per cent voids or 3½ cu. ft. with 50 per cent voids? When it is stated that each cubic yard of Concrete in place shall contain 1.7 barrels of cement, what limit is there placed on the adding or deducting of fine or coarse aggregate to maintain it?

Take the design of the section of slab using the thickened edge, why have the change in thickness so sharply made, making it impossible to cut and maintain in actual practice? A gradual change in depth in the nature of a curve would make a workable design and give the same results, the only difference being that the extra concrete necessary would be taken into consideration when the end area is figured and provided for, and not lost in construction by the contractor. and considered as overrun.

When a deduction is made from the contract price, for variation in depth of slab below that specified, why isn't additional payment made for increased depth within certain limits, or quantities added to care for it? Why not include an item in proposal to cover overrun and underrun of pavement depth; payment on same to be made in accordance with clauses safeguarding the State against carelessness of the contractor in construction, but safeguarding him where variations occur in spite of his honest efforts to prevent them?

Where such uncertainties and conditions exist, and a contractor is not permitted to save himself by applying safe and certain safeguards entailing no loss in quality of concrete produced, he is due for a loss in materials over and above the amount theoretically necessary for the concrete to be placed even though the cement factor is not exceeded.

In connection with the divisions as made, a supplement might be added dealing with the factor of cooperation and understanding between the parties most interested in the subject, the engineer and the contractor. Both should recognize the position and desires of the other and strive to wipe out doubt and uncertainties as to the results sought and an honest effort in carrying out the construction, will do wonders in stopping overrun and underrun of materials.

Assuming that the specifications have been established, from the time that shipments of cement and aggregate are started to the job, the contractor, with the assistance of a competent inspector, should begin at once to exert every precaution to prevent overrun or loss of materials.

Items to Control

The following items should be carefully observed and controlled to obtain the maximum saving in materials.

Checking shipments of material as to tonnage and quality.

Storage of material and safeguarding against weather.

Specification requirements for large amount of materials in storage ahead of construction.

Number of times aggregates are handled entailing loss with each handling.

Measurement of aggregate: Bulking action of sand; Variation of voids in coarse aggregate.

Number of handlings of cement with loss for each handling.

Method of delivery of batched material to mixer and effect on Condition of prepared subgrade.

Subgrade:

Soil conditions.

Weather.

Whether a graded section or not.

Fine Grading:

Soil conditions.

Care with which rough grading has been done.

Method of setting forms and resurfacing.

Subgrader.

Specification for rolling, and watering.

Cross section of completed subgrade.

Method and specification for testing subgrade.

Mixing and Finishing Pavement Slab:

Stability of side forms.

Correctness of finishing template.

Consistency of Concrete.

Method of finishing.

Wastage over forms.

Due to the lack of time for the presentation of this discussion, the remainder of this paper will be confined to the more important of the items, enumerated in the above outline.

Cause of Overrun

A survey was made of many State Highway Departments from Coast to Coast, and in reply to a questionnaire the consensus of opinion attributes the cause of overrun to two main items.

First—The Measurement of Aggregate.

Second—The Correctness of the Subgrade.

The replies also indicated the interest and effort that is being made to meet the conditions and eliminate the objectionable features connected with the problem of overrun of materials, including cement, in highway construction.

First, under measurement of aggregates, we will discuss the bulking action of sand. It is well established that fine aggregate or sand is subject to bulking due to the natural moisture contained. It is safe and conservative to assume that when a cubic foot of commercial stock pile sand is measured out loose in a box, the volume of sand will shrink about 25 per cent if the sand is either completely dried out or saturated with water.

This is exactly what takes place on the paving job where bulking is not corrected. The bulk sand is introduced into the mixer drum together with the cement, gravel or stone, and water. Immediately when the sand and mixing water make contact a decided shrinkage takes place.

Let us examine the effect on quantity of materials used.

Assume a six bag batch of 1-2-3 mix which would nominally contain six sacks of cement, 12 cu. ft. of sand and 18 cu. ft. of coarse aggregate. The sand, when measured by volume without correction for bulking, will shrink to approximately 9 cu. ft. and instead of placing 36 cu. ft. of sand, coarse aggregate and cement into the mixer for each batch, there are only actually 33 cu. ft. present. It will be found that the yield of concrete suffers a loss on this account of over 8 per cent, and it is almost directly proportional to the true volume of materials going into the batch.

Taking a mile of 18 ft. concrete road of 7 in. uniform thickness, we find that a six sack batch, of 1-2-3 mix, is designed to build 2.266 lin. ft. of such pavement. Actually when bulking sand is not corrected it will only build 2.075 lin. ft. of slab. Theoretically there would be required 2331 batches to build the mile of pavement, but due to the bulking of sand 2,545 batches will be required. If this bulking is not corrected this is what happens.

The extra cement used is (2545—2321) x 6/4 equals 321 bbl.

The sand saved is (2331x12)—2545x9 equals 187.6 cu. yds.

The extra coarse aggregate is (2545—2331)x18/27 equals 142 cu. yds.

The amount of bulking will be from 20 to 35 per cent, depending on the nature of the sand and the moisture present. Reference is made to the magazine "Public Roads" dated July, 1924, citing the entire data regarding the bulking of sand both out on the job and in the laboratory. There are numerous other authoritative references on this subject.

This bulking of sand should be corrected. There are now definite and accurate methods which accomplish this. In volume measurement of sand the measure can be set sufficiently large to correct for bulking. This involves a careful watch of the condition of the sand so that correction for bulking will be consistently accurate, under the varying conditions.

The weighing method has been adopted or is permitted in a number of States (California, Iowa, Tennecesse, South Carolina, New Jersey and Missouri).

Under this method the batch of sand is weighed out as so many pounds based on

the dry weight of the material without regard to the volume condition of the sand in the stock pile or cars.

A further refinement of the weighing method is to allow for the weight of water in the aggregate. This is ordinarily done by ascertaining the average moisture content of the sand.

A sample of the stock pile sand is weighed, then dried over a fire and again weighed bone dry. The loss in weight due to evaporation of moisture is then taken as the percentage of moisture by weight for the stock pile. This is a simple practical test which can be performed rapidly, without any complicated equipment and with great ease. The batch weight of sand is increased sufficiently to correct for the weight of water contained in the material.

If the stock pile varies in moisture from the average condition assumed, the error introduced is far less than where the material is being measured by volume, as the bulking fluctuates rapidly with changes in moisture content.

The weighing method has been practically applied to concrete paving operations with great success. From the contractor's standpoint, weighing of aggregate involves no delays in the operations. Equipment has been perfected for more than three years to weigh aggregates with no loss of time other than that required with a batcher.

Inundation

Within the past year the Inundation System has been perfected and marketed for measuring fine aggregate in a saturated condition. Saturation automatically destroys the bulking of sand and places it in a condition where it can easily and rapidly be measured by volume.

Inundation shrinks the sand to a constant volume basis just as if it were bone dry and not bulked. Inundation further brings each batch of sand up to the point of saturation, thus nullifying the effect of varying moisture content of the sand on consistency. This enables the contractor to control the consistency of the concrete with greater ease. The application of the Inundation System to Highway Paving has not been thoroughly worked out as yet, but it appears to possess enough inherent merit to deserve consideration as a means of controlling the quality and economy of concrete. The outstanding feature of the Inundation System, is that it destroys the bulking of sand and insures correct water measure without any tests whatsoever as to the natural condition of the aggregate, this recommends inundation to all contractors and engineers as a safe means towards preventing the overrun of materials.

Correct measuring of the coarse aggregate as far as actual volume is concerned has been well taken care of. Practically all trouble encountered has been a result of the grading of the material by the producer, or if delivered correct in all respects by him through separation of coarse and finer, due to improper handling by the contractor. The variation of grading in coarse aggregate also has its effect on the yield of concrete. If the cement factor is based on a normal grading of coarse aggregate from ¼ to 2½ ins. in size, and the grading changes so that nearly all the fines or material below ¾ in. is omitted. The reduction in yield of concrete will be approximately 4 per cent (See "Public Roads," July 1924, page 23).

In actual costs this means about one-half of the overrun of materials computed under bulking of sand. Contractors have been lax in their attention to the materials delivered to them for use in concrete, particularly in regard to coarse aggregate. They have not considered the question of choice of kind, nor have they, after purchase, inspected or tested to determine for themselves whether the aggregate they are paying for does come up to the specifications under which it was purchased; neither do they give the attention to the handling of coarse aggregate that is necessary to secure the best results.

Materials passing the specifications on board cars can be changed into various gradings by handling and storing, and correct materials properly stored can be rehandled in such a way as to almost wipe out the efforts that have gone before.

This is not the right attitude necessary to prevent overrun. Contractors should insist on everything necessary being done by their organization on a job to correct it.

Coarse aggregate is usually condemned by the engineer for other reasons than for lack of fines. Material producers know that an excessive addition of fines will cause their product to be rejected much more quickly than through lack of them. Therefore, they will play safe along that line, to the cost of prevention of overrun

As to the choice between crushed stone and gravel, much has been said as to the results obtainable in their grading under

present methods of production; also as to the effect of the use of either on quantity and quality of concrete produced. This also is worthy of investigation.

As proof of the extent to which fines are lacking, one of our leading Eastern State Highway Departments estimates that 50 per cent of the coarse aggregate for their paving work was deficient in the small sizes of material, and of course a corresponding loss was suffered in construction.

Effect of Grade

In discussion of correctness of subgrade grade, and its effect on overrun, it will be necessary to consider first the weather, soil conditions, and the skill used in completion of rough grading, as three very important factors.

Wet weather is a destructive force hanging over the entire construction process and affects overrun or underrun to a greater or less degree depending on the soil conditions, method of delivery of batches to mixer, the season of the year and duration. When hauling is done over subgrade by trucks on certain soils, the only sure way to prevent overrun or underrun is to stop placing of concrete until suitable conditions exist, or plank the subgrade to prevent its destruction.

Rough grading built with care, brought to as near final grade as possible, for the full width of the roadway and sufficient distance outside of form line, will tend greatly to reduce overrun.

Rough grade should be kept uniformly high always, assuring that in the setting of forms that they will not rest on a fill, and that all fine grade be made in cut, without the moving of excess earth. That most contractors do not draw the distinction close enough between rough grading and final subgrading is made evident by a visit to their work. Usually it is found that instead of a small force turning a well prepared rough grade in to a stretch of completed fine grade, that a mixture of teams, tractors and men are more or less rough grading betweel the forms and that all is haste and hurry, with resultant losses through faulty formsetting and subgrading.

Selection of Forms

The selection of forms suitable to meet the conditions to be encountered is very important. Forms that will serve with certain soil conditions are not fit for use on others. Selection should be made with the following qualifications in mind.

Section must be strong enough to take loads and impacts of subgrader and finishing equipment without deflection or distortion, and the areas of base of form sufficient to sustain the required load upon the particular soil encountered.

Design of form must be such as to withstand side thrust of subgrader and finishing equipment and the lateral thrust of concrete.

Staking arrangement should be such as to give added support to side form over and above that provided by the subgrade by means of a locking device, a positive and effective method of fastening joints and preventing deflection at that point. Staking method and locking device between forms should also be such as to enable easy readjustment.

Forms should be carefully set tight to line and slightly above grade before subgrading operation. If displaced by subgrader care must be used in resetting and surfacing. Usually on account of the effort necessary to remove forms and retrim directly under them, the practice is to resurface to high points by the raising of the other sections, resulting in many instances in increased thickness of slab.

Too much attention cannot be given to forms and form setting. Investigation will show that increased width and excessive or insufficient depth of slab are bound to follow lack of attention to this item. It is suggested that forms be set upon stakes driven to grade where the soil conditions are so poor that the form cannot be supported otherwise.

Subgrading machines, of which there are several types, are not made for heavy excavation as most of us have found out, but should be used for light trimming. If used with care, making a gradual approach by light cuts to final grade, low subgrade will be avoided, and the form line kept in almost perfect condition.

Tests should be made on subgrade to find out the amount of compression due to rolling that must be allowed for. This is important and will depend on the weight of roller required, the soil conditions and may further be affected by requirements of specifications as to the amount of rolling specified.

Several states require the final cut on subgrade to be made between the mixer and the place of depositing concrete. This is accomplished by attaching a special make of subgrading template to the mixer, that is pulled forward at each move of the paver.

Satisfactory results tending to correct overrun are obtained by this method if

the subgrade has been left uniformly high, taking into consideration that only a very light cut can be made for final completion by the drag template. In case of low subgrade no filling is allowed, therefore no result is accomplishel other than that it is apparent that extra concrete is being placed.

As stated before, contractors must remember that there is a direct bearing of one operation upon another in the final effect on overrun and underrun of materials used, and that the correctness of the subgrading operation is the climax in the prevention action.

A summary of recommendations to assist in a solution of prevention of overrun through subgrade deficiencies should include a requirement for additional footage for forms set and subgrade prepared, watered and rolled ahead of paving operation; with requirement that all subgrade be made uniformly high and to proper section for final completion by drag template; the stopping of all hauling directly on prepared subgrade; a further refinement of the subgrading machine; changes in length of mixer boom and design of bucket to enable further development and use of drag template.

The effect of incorrect methods of mixing and finishing upon overrun and underrun is less than the other operations mentioned and are subject to correction much more readily. Consistency of concrete should be kept well within the range of a workable mixture, dependent on the ability of the finishing equipment to handle it.

Finishing machines will successfully handle concrete produced under the slump tests usually specified, if the grading of aggregate in the mix is correct, and will do so without loss over sideforms. However, care must be used in checking strike off and tamper as to their correctness in crown and shape with respect to finiished surface as specified, and their adjustment one to the other. This check should be continued throughout the laying of pavement as it is impossible for adjustment of strike off and tamper to become loose and drop, or an operation in adjusting the machine to reset higher than necessary. Also watch that the scrapers that are supposed to clean the top of form ahead of finisher wheels are adjusted so that they do provide a clear track for the machine.

In operation of finisher a regular procedure should be worked out and followed. It is the tendency to do as little with the finisher as possible. The average operator has no idea of the importance of the position he holds in its effect on overrun, and in his efforts to carry out his instructions "To keep up with the mixer," does a haphazard job of striking off the concrete.

Even the puddlers or levelers also play their part in preventing or helping overrun occur, preventing by careful leveling the batches making it possible for the finishing machine to do its work correctly, and stopping unnecessary spilling over top of forms, or helping by careless leveling that forces the finishing machine to do extra work with a sacrifice of concrete in wastage and extra depth.

Few contractors have figured out the loss (overrun) caused by a variation of ⅛, ¼, or ½ in. in thickness of pavement. When they do awaken to the facts, losses from overrun will receive concentrated preventive action.

Again, contractors do not want to lose sight of the fact that prevention or stopping of cement overrun means stopping of losses in the other material as well; that the preventive action is a step by step process in construction with a successful ending dependent on a knowledge of effect of each step on the result obtained, and their connection and importance to each other. Also that application of this knowledge in construction required positive supervision and checking throughout the entire job.

Lack of information has been the cause of the attitude of the contractor towards the inspection and supervision of the engineer. The contractor, fighting for production, has viewed certain requirements only from the side of immediate cost in labor, while the engineer saw beyond to the result on materials and quality. It is more through their efforts and guardianship that our attention has been called to the importance of this subject to us in construction.

It is unfortunate that lack of time forbids the reading of replies from the various state highway departments, who so kindly answered the request of the writer by letter, giving the view of the Department on the stopping of cement overrun. They are, however, included for publication. In closing, however, certain statements from them must be included.

1. "Our experience has been that contractors use from 1½ to 1.6 barrels per cu. yd."

"We still have contractors who will not cooperate with us in watching details even after they have been advised re-

peatedly that they are using too much cement"

2. "Recognizing the difficulty of making perfect subgrade, we pay for extra cement used due to low subgrade as noted in specifications; Basis—5 per cent of theoretical amount required by authorized cross section."

"Require all forms to be set on 2 x 3 in. stakes driven to line and grade."

3. "The most important factor in the matter of cement overrun from the view point of the Contractor is its relation to the yield of Concrete per batch. As the cement factor and the calibration of the batch meter affect the yield, the contractor has a direct interest in these items."

"Average overrun on 20—1924 contracts was 2.65 per cent. Batch meters given preliminary adjustment at beginning as nearly to correct volume of coarse and fine aggregate as possible. A batch of material was run through batch meter into a special box whose volume could be easily determined. These boxes were hauled a distance equal approximately to average haul on job. A certain amount of settlement would occur in both sand and stone due to jolting. Material was added at end of haul until the box again measured the correct volume for the batch used. Batch meters were then corrected to contain the additional amount of material."

4. "It seems that the solution of this problem is: the careful and conscientious supervision by an experienced Engineer and Construction Superintendent."

"The principal factors entering into the prevention of overrun or underrun on cement are the correctness and evenness of the subgrade preparation and proportioning of the batches.

"We do not feel that any special provisions or means are necessary, except the care in manipulating the equipment which is usually on the job."

5. "A well graded coarse aggregate and well formed fine grade are the best cure for cement overrun.

"In this department we pay for the cement per barrel as a separate item and pay only for the amount that is actually used."

6. "Average overrun during 1924 was 6.57 per cent. The cross section of the subgrade used last year was a combination of plain and curved surfaces which required considerable care in preparation.

"Suggested means of prevention or overrun: Eliminate hauling from subgrade. Cut the subgrade true to required cross section by mechanical devices where subgrade material will permit. Strike off surface of concrete carefully to required contour. Use properly graded fine and coarse aggregate and the most positive means of proportioning."

7. "Our experience on contracts shows that cement overrun in any amount is due to one cause alone: careless subgrading.

"Twelve contracts chosen at random, core drill records, showed a variation of from ¼ to 1 in. additional thickness. One contract showed over 1 in. average thickness above that specified for entire project. Variation in cement allowed 1.5 barrels minimum, 1.65 maximum."

8. "We have no special provisions or means of preventing overrun or underrun of cement.

"It is our opinion that one important factor in overrun can be traced directly to bulking action of sand; another the gradation of aggregate. Coarse aggregate as received from producer varies in void percentages and for that reason we believe that it is an impossibility to ever use exactly the right quantity of cement in a paving job.

"Waste over forms and spreading of forms are also factors that cannot be ignored."

9. "In as much as practically all engineers include in their cost analysis items covering sack losses, storage, and etc., there is no reason why the contractor should not recognize the item of loss of cement, but we have yet to see the contractor who dealt with this feature in a systematic manner.

"We cite one loss of 40.5 barrels, 162 sacks, in 720 ft. of 16-ft. road, 7.25 ins. average thickness, an overrun of 8.98 per cent. Traced to 3.45 per cent to subgrade or ¼ in. low, method of measure 5.19 per cent and 8 extra sacks required by inspector for lumpy cement—0.44 per cent.

"We provide for bulking action in 1925 specifications. We specify a minimum number of sacks, 6¾ to each cubic yard of concrete instead of making it an exact proportion. For some aggregate we have to increase the cement proportion in order to use this number of sacks to the cubic yard of concrete."

10. "You will note that our specifications require our aggregate be weighed. You will note that in our specifications no mention is made as to the quantity of material required per cu. yd. of concrete. This means that the specified proportions govern and that the proportions are not

varied to make the amount of cement used per cu. yd. constant. You will note from the specifications that we require that the minimum depth of pavement slab shall be 8 ins. Since it is impossible to secure a perfect surface on an earth subgrade, it is inevitable that if the specifications are strictly enforced the quantity of material used will be greater than the theoretical quantity for a slab uniformly 8 ins. thick. The difference between the theoretical quantity and the actual quantity of materials necessary to produce a square yard of pavement seems to be quite well established in this State and does not vary greatly. For this reason it would seem to us that the contractor should include this item in his bid. He should not forget that this excess above the theoretical quantities affects not only cement but all other materials and has a corresponding effect on all construction items except subgrading, forms, finishing and curing.

"Our object in supplemental specifications is to provide the contractor with such data as we have which will enable him to intelligently figure this item."

11. "We have not compiled any data showing the overrun or underrun of cement on paving work. Our specification allows a variation of 7½ per cent from the theoretical amount required, and as the contractor is required to purchase and furnish his own cement we have not found it necessary to keep as close a check on this matter as we would have otherwise."

12. "We believe the major portion of overrun and underrun is caused in measuring of aggregate. We intend to provide in our new specifications for proportioning by weight. We believe that it will result in a more uniform pavement and help control our cement factor.

"We require subgrade to be left high, and a steel template attached to mixer and pulled by it to plane off the excess earth just before the concrete is placed.

"On three projects during 1924, involving from 4,000 to 10,000 cubic yards of concrete, the cement ratio varied from a minimum of 1.38 to a maximum of 1.58 barrels to the cubic yard for daily variations, average for jobs being 1.48 to 1.51 barrels. One job showed an overrun of 5.4 per cent for a single day.

"If material is not measured correctly it would be very difficult to prevent overrun or underrun of cement.

"We lean towards improved methods of measuring for 1926."

THE ROAD CONTRACTOR'S PRECARIOUS CALLING

By A. R. Hirst, Chief Engineer, American Vibrolithic Corporation, Des Moines, Iowa

(Editor's Note: The following paper was read by Mr. Hirst at the annual meeting of the American Road Builders Association at Chicago, January 12, 1926. His subjert was: "Estimating the Job", but he said very little on that topic. He explained his departure from his assigned subject by saying that if a contractor estimated his job intelligently he would bid so high that he would never "land" a job. It is a sad commentary on the present status of the contracting business when a man of Mr. Hirst's experience and enthusiasm does not think it worth while to discuss intelligent estimating.)

All contracting is gambling. Paving contracting is an especial gamble, even in city and village street construction. Under existing conditions, rural highway construction should hardly be dignified by calling it a gamble. Unless an especial contractor has the cards stacked somewhere in his favor, consistent profits from State, County and Federal highway work are so precarious that in the long run one has about the same chance of winning that one has if he plays slot machines for a livelihood.

A Mad Stir

During the past few years tons of good white paper have been covered with exhortations to highway contractors to get together and instruct themselves and their brethren how to bid so that all jobs would be profitable to the successful contractor. Contractors associations have sprung up, lived, or died, their motto ever being "Make the Contracting Business Profitable."

Equipment and material companies, technical magazines, and many engineers and their associations have turned their attention to the problem of eliminating the irresponsible, untrained, unfit, underequipped, or super-optimistic contractor from the field.

Brains and money have not been lacking in the quite sustained effort to improve the conditions under which highway contractors operate. All without apparent results. To one who has been quite familiar with the field of pavement contracting for 20 years, it seems that in 1925 the conditions and prices have been relatively worse than at any time in our history.

Certain contractors have always had certain special conditions set up in certain localities, either by the legitimate use of proprietary pavements, or by the especial merit of their work, or by means which we need not discuss. Usually these contractors make a reasonable profit, because they are masters of their own destiny and by one means or another they have eliminated the suicidal knifing of jobs. The ethics of some of these solutions we shall not discuss. Sufficient to say that every man has a right to safeguard his livelihood and his investment within legal limits. To anyone who really knows the pavement field it must be obvious that the only pavement contractors who consistently make a good livelihood or more are those who are not thrown into the maelstrom of irresponsible competition on every job they bid.

On the jobs open to the world chaos has ruled. It has been possible for almost anyone to qualify, even where qualification was ostensibly required. There are still scores of angels with more money than brains, who look at the apparently big paving prices and confuse prices and profits. Any foreman or engineer who has laid a few thousand square yards of pavement feels that he is perfectly qualified to bid and build jobs. He finds an angel; the angel finds some money; some machinery company will sell to anybody; material companies will furnish anybody; some bonding company will bond anybody; almost any municipality will award to anybody who is the low bidder and can furnish a bond. And Presto! We have the Tanlac Engineering and Construction Company; the Tanlac Company has a job; and the public at some unknown time will get some kind of a highway improvement finally built.

In case the job is open to the world, not an occasional job, but almost every job is awarded at prices below what even the most optimistic, though sane, contractor could figure as cost, if all the dozens of items which should be figured into cost were really included. Of course, there have been cases, even in 1924 and 1925, where lucky contractors have gotten really profitable contracts as events came out, but these cases are so few and far between that they provide very little brightening to the general picture of great loss, breaking even, or small profits.

Why Theorize?

It does not appear advisable that we should all spend any considerable amount of time and energy in formulating and discussing the real fundamentals and the details of actual methods of estimating the expected real cost of a job, which detail must take in every one of dozens of items which together make up cost, when under present conditions the roughest approximations serve every bidding purpose practically as well. "Estimating the Job" is easy. The trouble is that good estimating never gets on except by a miracle. Today when an old timer gets a job he frantically digs over his papers to see just where he made a mistake and dropped out several thousand dollars. Usually he finds it.

I venture the assertion that when the compeition was absolutely open to the world in 1925, that in not one out of twenty cases did a pavement job go to a contractor who really estimated with knowledge and intelligence the cost of the job, then added a legitimate profit, and then bid just what his figures showed!

How a Bid is Made Up

From quite excellent contractors I gather the mental processes used in estimating a job are somewhat as follows:

"Yes, the Plank Road job in Silo County is up for letting. Eight miles, eighty-five thousand square yards. We need that job. Let's see. Last year we had a job in Corntassel County next door. Depth and mix the same. Soil about the same. The haul was a little shorter, and the engineer was very decent—for an engineer. I understand the engineer of Silo County is a member of the dog family. Last year we bid 80c for grading and $2.42 for paving. Came out quite a little behind but the weather was rotten. Weather should be better this year and they say labor will be plentiful and cheaper. Materials are the same price, and anyway, we may find that Rainbow sand and gravel pit is all right and make a killing. What say we bid 74c on the grading and $2.36 on the paving? What's that? Price Cutter and Awful Lowe both took out specifications and say they are going to sharpen their pencils right this time? Well, we need that job; in fact, we must have it. Our men and equipment are eating us alive waiting for a job. We will have to get our overhead, depreciation and interest out of the next job. Here she goes—grading 62c, paving $2.21. We'll show those confound blanks they can't come over here and take our job."

Overdrawn?—Possibly. Yet, judging by the prices bid a great majority of jobs are bid with not much more background than that intended. Prices at recent lettings,

prices on some recent previous job, the net outcome of which is known, the kind of competition, the time of the year of the letting, the urge or lack of urge to keep men and outfit going, have had a much larger influence on prices bid than valid estimates of cost plus profit. The best estimators are usually the poorest job getters. A real job getter has to be an optimistic Irishman, putting in his bid on a sunshiny day after he has attended the wake of a deadly enemy the night before.

What is behind all this? Put in a very few words, the cause of the perennially low stage of public pavement contracting is as follows: Competition open to the world with no price advantage given to the well financed, equipped and manned contracting organization which can, will and does furnish a good job, built on time without trouble, as compared to the "haywire" organization whose motto is "Muddle Through" and whose personnel, financing, equipment, progress and workmanship are alike on the narrowest edge of getting by.

Causes of Low Prices

Some of the contributing causes for low prices in the highway field are included in the following list:

1. Open competition with widespread advertisement of jobs.
2. No bonus for speed.
3. No bonus for workmanship or quality.
4. No bonus for freedom from trouble in conducting the job.
5. Materials furnished by municipality in many cases, thus reducing financing required.
6. No preference on materials due to too generous lien laws and bonding protection to sellers.
7. Natural desire of machinery companies to sell their goods to anyone.
8. The number of bonding companies competing for business, some of whom will bond anybody. Many of these companies, when in doubt, increase the competition by bringing in new bidders who will bond with them.
10. The gambling tendency of almost all true contractors.
11. Lack of continuous and consistent programs in most areas, leading to a building up of organizations and equipment during the peaks and a wild scramble for the few available jobs during the depressions.
12. General overcrowding of the highway contracting field.
13. General lack of really severe qualification of bidders.
14. The almost universal practice of giving any low bidder a job, providing he can furnish a bond.
15. Irresponsible and ignorant of cost sub-contractors who take details of the work from underbidding contractors at even lower prices.
16. Sales of motor trucks by some truck companies to anyone on shoestrings. These shoestring owners, totally ignorant of actual costs, subcontract hauling at far below cost, and give contractors who prey on their ignorance a great advantage over contractors who own their hauling equipment and know what it costs them to own and operate it.
17. The energetic, and usually successful, efforts made by most sellers of pavement material to bring in low bidders on their especial type of pavement whenever several types are in open competition. In fact, this sustained effort of many large producers of materials to lower pavement prices is one of the most serious phases of the situation.
18. Constant introduction of new firms, new blood, and new money, and the seeming necessity that most of these new performers get at least one costly lesson before they settle down to normalcy, or pass out.
19. Desire of poliitcally ruled municipalities to make a low price showing on the actual awards, regardless of the final outcome which can well be covered up.

The Remedy?

The Remedy? There is none remotely possible in my humble opinion. The man who can suggest an effective cure for the present evils would deserve from the highway contracting fraternity a reward greater than any man in the construction field ever received.

Deep down below this situation lies the state of mind of our whole people. They have been educated to believe that accepting the low bid and a profitable deal to the public are always the same thing. Public officials cannot long hold their jobs if they award to other than the lowest bidder. They cannot "sell" their people the idea that the contract amount is only one factor of both the total cost and the final cost. All jobs look about the same to the public. Most of them cannot distinguish between a rotten job, a fair job, and an excellent job. They grouch about delays and detours, but they grouch just as much about a few days as about many. The common man argues that with every-

body bidding on the same plans and specifications and with a surety bond required, the result must be the same whoever gets the job, and that if the contractor fails to perform, the bonding company must finish the job at the original price.

What We Need is a Better Public

There is absolutely no general public conception of the fact that with the same plans and specifications the value of the finished product legally delivered may well vary 50 per cent, if all factors of time, detours, traffic service, and the quality and life of the pavement are taken into account. In the present public opinion "pigs is pigs", a contractor is a contractor, a pavement is a pavement. The contractor who just gets by is just as good as the one who is a world beater in skill, speed, and efficiency.

We will not have a widely different condition in the open field until the general state of the public mind is different—and I doubt whether it can be made to be different. The public gets most of its education on public questions from the politicians and the newspapers and it would be a brave politician or newspaper who would undertake any sustained campaign to raise the apparent cost to the public of public construction enterprises. Few engineers or public officials are brave enough to face the public wrath and the suspicion of grafting which always comes from an award to other than the lowest responsible (Heavens, how that word "responsible" can be stretched!) bidder. If contractors, material or machinery companies, bonding companies, or their associations publicly urge better prices to responsible contractors only, the average man says: "Ha! Of course *they* would advocate high prices, it means more money in their pockets." Intelligent striving for betterment is stopped at every turn, has been for years and will probably continue to be as long as human nature continues to be the same, and human nature is almost a constant.

Good Work by Sam Williams

There has been quite sustained and intelligent effort made in the last two years to improve the situation by providing for the real qualification of bidders, either in advance of the bidding or before an award is made. Mr. S. M. Williams, of the Autocar Company, has probably done more than any other one man to promote this much needed reform and a considerable advance is being made. However, on public work, so many exceptions can be made, have to be made, and are made, that the value of apparently rigid qualifications is nowhere fully attained. The semi-political atmosphere in which most public work is conducted is not conducive to the exercise of uninfluenced judgment of facts, even where the awarding body has the best intentions.

Little has been said about "Estimating the Job"—I am not going to say much. Years ago I was instrumental in having made up and published by the Wisconsin Highway Commision in cooperation with contractors and machinery and material men, a quite adequate cost sheet to be used in estimating the cost of rural concrete road projects. This sheet was much circulated and copied but has about disappeared from the field because it was really quite complete and contractors found that if they filled in all the items with intelligence and then bid the figures the sheet gave them, they never did get a job. They ceased to be contractors and became gentlemen of leisure.

I imagine the reason why there is little of this kind of information available now and why contractors' organizations have not devoted themselves to the task of formulating more adequate cost sheets, is because no one can use them. In preparing this paper I did a lot of work preparing cost estimating sheets but the results were so appalling and the answers gotten so at variance with prices bid that my work went into the waste paper basket.

If a contractor is going to stay in the open field of pavement competition, about all he nedes to estimate with is the current reports of recent previous awards in the area; a knowledge of who is going to bid; an Ouija board; a rabbit's foot, and a good bank account.

Someone says, "Stop kidding us and give us something constructive tending to eliminate the present evils." Well, if you must have it!—Conditions will be improved when most of the nineteen previously listed causes of the present conditions are partly removed or totally eliminated.

Highway contractors are, many of them, in the game to stay. They have to be, because their all is tied up in it. They play the game because it is the only game they know. They are like the cowboy who got in a crooked poker game in a mining town. When told by his friends that the game was crooked, he replied, in surprise, "Hell, it's the only game in town isn't it?"

The Final Trimming

Most of the good contractors have pulled through so far and they will prob-

ably continue to pull through until they get the final trimming which is almost inevitable if they bid so as to get jobs in the present market. The Lord does love a contractor, but the Lord also loves those who help themselves. It is up to the real highway contractors really to start something that will help themselves. Just what requires deep consideration by the wisest heads. Certainly nothing so far started has resulted in anything which has very greatly helped the situation. Obviously, before there can be any general relief many different kinds of people, all factors in the situation must be educated. Education costs money and takes brains on both ends of the line. Above all, the whole public must be educated. That takes national advertising, and national advertising costs real money.

Does the Author Refer to Bonding Companies?

In my opinion, the interests which should be allied to contractors have not cooperated as they should to improve conditions, but on the contrary, many of them have materially helped to make them worse. The producers and sellers of highway materials, the manufacturers and dealers in machinery and equipment, the bond and insurance companies, and the banks, should all be interested in stabilizing this great industry. They should help in removing from it the unfit and disturbing elements by refusing to accept their business. Means should be taken by reputable contractors and their associations to insure the full cooperation of these allied interests by appropriate methods. Those who are not with stabilization are against it, and should be treated accordingly.

In conclusion, it is my impression that there is no collective way out of the present morass which can possibly give immediate results. Small groups of contractors can, in many cases, work out individual solutions for limited areas which will give immediate relief. Any real result can only come with the elimination of irresponsible competition in the area. As long as the competition is open to the world with the awarding body taking into account nothing but the prices bid, there can be no adequate reward for competent service, workmanship, speed and value of product. In my opinion, the really competent and able contractor who stays in the wide open public contracting field is wasting his time and his talents and is unfair to himself and to his dependents.

To reiterate, the answer is not collective. It is individual, and each contractor or group of contractors must work out the answer in their individual area. The sooner good contractors stir themselves to find this individual answer the more money they will have with which to escape the poorhouse, if 1924 and 1925 have left them anything more than their happy dispositions.

One of the very best solutions for competent contractors is to get entirely out of the public contracting game. There is much private contracting on which service, ability, workmanship and speed, does count. In fact, public work is about the only building operation which places no added price value on any of these things. I earnestly advise public work contractors to seriously consider transferring their operations to the field of private work, where ability to deliver the goods often counts high, and where the dollars and cents of the apparent first cost is not the sole yard stick of value used by the buyer.

ECONOMICS OF HIGHWAY EQUIPMENT STANDARDIZATION

By C. H. Powell, Secretary, Sternberg-Powell Co., Chicago, Ill.

"Economics of Equipment Standardization" is simply a sub-division of the broad subject "Elimination of Waste Through Simplification and Standardization." Not waste in the sense of willful waste but economic waste which is the natural outgrowth of a competitive system; not the waste that any single individual can correct by his own initiative, but the waste that can only have remedy in collective action; nor the waste which can be corrected by any extensions of the Ten Commandments or by any legislative extension thereof. "You cannot catch an economic force with a policeman." This waste is not the small change of industry and commerce. The possible and practical savings from such elimination is not figured in millions but in billions of dollars.

The benefits which have accrued from accomplishments in the elimination of waste through simplification and standardization in the last few years are recognized as a great factor in our prosperity today, although I daresay very few of us are able to comprehend or have a complete knowledge of the vastness of this undertaking. The cumulative benefits flowing from the establishment of the Di-

vision of Simplified Products in the U. S. Department of Commerce nearly four years ago are now reflected in our national prosperity and recognized by bankers as a factor in our present financial position. Secretary Hoover by this one act alone has well earned immortal fame in the history of American business. By force of inertia, however, the old order of things would doubtless have endured indefinitely in the absence of some agency whereby producers, distributors and users could come together and agree to standardize, simplify and minimize the excess variations in shape, size, quality, process, composition and other characteristics of many products.

Standardization is accepted as an economic necessity in the construction industry. As an example, since 1921 paving brick sizes have been reduced from 66 to 5 and production in the industry has increased from 210 million bricks in 1921 to 460 million in 1924, and 88 per cent of the 1924 production adhered to the five sizes. No information is available as to the saving thus effected but in the lumber industry, which eliminated 60 per cent of the variation in sizes, the industry estimates a saving of 200 million dollars a year.

The important role which standardization plays in industrial evolution is not generally appreciated. Some of the significant aspects of standardization when carried out on a sound engineering basis are:

1. It enables buyer and seller to speak the same language and makes it possible to compel competitive sellers to do likewise.

2. It increases quality of product through ability of the manufacturer to concentrate on better design and through the reduction of manufacturing expense.

3. It lowers unit cost to the public by making mass production possible, as has been so strikingly shown in the unification of incandescent lamps and automobiles.

4. By simplifying the carrying of stocks it makes deliveries quicker and prices lower.

5. It decreases litigation and other factors tending to disorganize industry, the burden of which ultimately falls upon the public.

6. It eliminates indecision both in production and utilization—a prolific cause of inefficiency and waste.

7. It stabilizes production and employment by broadening the possible market and by making it safe for the manufacturer to accumulate stock during periods of slack orders to an extent which would not be safe with an unstandardized product.

8. By focusing on essentials it decreases selling expense, one of the serious problems of our economic system.

9. By concentrating on fewer lines it enables more thought and energy to be put into designs so that they will be more efficient and economical.

Applying these advantages directly to standardization of construction equipment the contractor would gain in better prices than would otherwise be possible, better quality of product through ability of manufacturer to concentrate on better design and through the reduction of manufacturing expense, the producer could and would give better service on the completed machinery, repair parts and deliveries.

The gain to the manufacturer is even greater than to the contractor yet it seems they are slow to appreciate their opportunity. Let us enumerate some of these advantages. The manufacturer would gain in having less capital tied up in materials, semi-finished stock, finished stock, jigs, dies, templates, special machinery, factory space and repair parts, in more economical manufacturing through larger units of production, reduced number of manufacturing units, longer runs, less frequent change, higher rates of individual production, accurate and proper estimating of production, more effective stock control, better and more simplified inspection, less idle equipment and reduced amount of equipment, reduced overhead, simplified and more accurate cost accounting system, elimination of waste in experimentation and design, in more efficient labor, better service to the trade, more efficient sales force, increased rate of turnover, intensive sales momentum, easier financing, fewer factory shutdowns, by compelling attention to individuality in those features where there should be individuality, by preventing attempts at individuality in those features where individuality is superfluous and useless and where standardization and quality should prevail; in earlier plans and schedules, and in a decrease in the number of production processes.

If the time ever comes when construction equipment is standardized additional advantages will doubtless be found, and the contractors, engineers, architects, and the manufacturers themselves, will won-

der how the construction industry ever functioned at all under the conditions existing today. Look back 15 to 25 years in the materials of construction field to the time, for instance, when there were no standard specifications for the different grades of steel or for Portland Cement. Would the contractors or the engineers, or architects, or the manufacturers, go back to the old order? Why there were almost a countless number of specifications all differing in some respect for Portland cement and the industry was in utter confusion trying to make a product to meet each individual specification. Now, thanks to co-operative efforts through the American Society for Testing Materials, there is just one specification for Portland cement. The industry enjoys many, if not all the advantages just summarized and the consumers are reaping their benefits as well.

There are upward of fifty major items of construction equipment upon which a great deal of standardization work can very profitably be done. When one reflects that perhaps the largest single investment the contractor has is equipment, and at the same time one of the longest time investments, one is forced to the conclusion that good management demands that this equipment represent as nearly 100 per cent efficiency as possible. Business is a moving thing, and if the construction industry is to keep up with the procession it must do as other industries are doing—eliminate the economic waste.

There can be little doubt that the standardization of contractors' equipment is an economical necessity. There seem to be two distinct functions in this work. First, the simplification of sizes and variations, and secondly the standardization of capacity and possibly some of the mechanical features. The logical procedure would seem to be first to eliminate the unnecessary sizes and variations and then go on to the standardization of the items which remain.

To the best of my knowledge the outstanding concrete example of standardization of contractors' equipment is the standardization of concrete mixers and pavers by the joint action of the A. G. C. and the Concrete Mixer Manufacturers. Those acquainted with this accomplishment know how long it took and the almost insurmountable obstacles that were overcome. This work was started several years ago by the manufacturers themselves and very little progress was in evidence for a long time. The work has gradually developed, however, until at the present time practically all of the concrete mixer production in the United States is represented in the membership of the Mixer Manufacturers' Bureau of the A. G. C. and out of the work has come seven standard sizes of building mixers and three standard sizes of pavers which have been standardized as to capacity and are guaranteed by the mixer manufacturers to have certain working capacity designated by A. G. C. standards. The economic value of the mixer standardization is apparent in the elimination of much of the confusion and misunderstanding between the buyer and seller in respect to the working output of various machines and the basis of quoting prices. This situation confused the contractor not only in selecting a suitable machine but also in comparing the different machines in respect to both price and capacity. Heretofore, in reality experience was practically the only true means of knowing the actual capacities and variations between the different makes. Now the manufacturers can concentrate their efforts on the essentials, which will do much to make this class of the contractors' equipment more nearly 100 per cent efficient.

Much confusion exists today in power shovel and crane equipment. It is not intended to single this class of equipment out as needing standardization more than any other but it is used as an example because I can illustrate the point I want to make better perhaps than with some other line. Specifications of shovel manufacturers with reference to the size of dippers have been been put on the same basis; some rate their dippers on "heaped capacity" loads while others use "struck measure" ratings. The bail pull and dipper speed is another factor in need of standardization among the manufacturers. In cranes there is no uniform capacity ratings which affords the prospective buyer a basis of direct comparison nor is the overturning factor of safety always shown in the specifications, nor is the line pull at various speeds listed in all crane or dragline ratings or the same "rig up" used as a basis. Crane or dragline ratings are not based on bucket sizes and boom lengths, giving the actual weight of buckets, stating the working radius at which each car can be used; nor is this always referred back to the overturning factor of safety. Another lack of standardization in this type of machinery which is confusing to the contractor buying such machinery is considerable varia-

tion in the method of figuring bearing pressure of the caterpillar type equipment. Some manufacturers use the net contact on a hard surface, others make a varied allowance for settlement, thereby figuring in a portion of the tread in contact with the ground which never touches on solid ground.

Another thing which the contractor has to look into carefully now when buying shovel, crane or dragline equipment is the power on the machine. How many manufacturers where gasoline engines are used give the following information: Make and type of engine, number of cylinders, bore and stroke, together with the rate of H.P. at a specified R.P.M. It is said that if this matter were checked up it would be found that a half dozen manufacturers now using exactly the same motor are quoting their machines with six different rated horsepower. The standardization of a few of these things would materially assist the contractors in avoiding many of the sad awakenings experienced by finding that a machine, after they get it on a job does not live up to the expected ratings.

Is it not apparent that in some cases there is an excessive and superfluous number of sizes in equipment that could very profitably be eliminated with a consequent saving? Do we need, for instance, four different sizes of shovels varying in capacity by one-eighth of a cubic yard? Would not two sizes do just as well? And then how about road graders? They are available now with blades 5-6-7-8 9-10 and 12 ft. in length. Why? And road rollers are now made in 3-4-5-6-7-8-10 and 12 ton sizes. Why? I venture to say that while the contractors may be responsible for the 57 different varieties in blade graders, the roller menagerie, from the 3-ton "pup" on up to the 12-ton elephant, belongs to engineers.

This brings us to the question of how standardization in the equipment industry may be accomplished. There is no miracle panacea that will overnight bring about the needed standardization. It can be made only through toilsome building step by step in a thousand places and always and only through the co-operation of the engineer, the architect, the material manufacturer, the contractor and the equipment manufacturer, by education to the necessity and benefits; in other words, by a lot of hard work. The procedure necessary to bring about a standardization in the equipment industry has been formulated and proved successful in the advancement made in other industries where the work is well under way.

The lack of contact, understanding and co-operation between the manufacturers who produce equipments or materials, and contractors who utilize these products, and engineers who draw specifications for work to be done, has bred much instability and inefficiency in construction, which is directly reflected in the basic industries. Great sums of money spent by manufacturers in developing and introducing new equipment or new materials, which is eventually reflected in the price of the equipment or materials, could be saved through the closer contact with the contractors; and likewise great sums could be saved by the contractors by lending their experience and constructive thought to the producers in these basic industries. With little comprehension of the fact that both manufacturers and constructors are in reality interdependent elements in the common enterprise of construction, these two groups have too long pursued their courses independently and perhaps viewed each other suspiciously when recognition of their common interest in the industry would react advantageously to both.

The four inferests enumerated above have a common objective which is a continuously functioning construction industry, cleared of wasteful or unsound practices, relieved of unnecessary production distribution and selling expenses and governed by the spirit of proper co-operation.

The time given me for the preparation of this paper was entirely too short to present it as I would have liked and to have developed any original ideas or thoughts on the subject. It is rather a compilation of material and ideas furnished me by a number of contractors, equipment manufacturers and the A. G. C., who recognize the importance of the subject and to whom you and I are indebted for the thoughts here presented.

The foregoing paper was read at the 1926 meeting of the American Road Builders' Association.

COMMERCIAL VEHICLES ON FREE HIGHWAYS

By Thomas H. MacDonald, Chief, United States Bureau of Public Roads, Washington, D. C.

(Editor's Note: The following article is reprinted from the Journal of Land and Public Utility Economics for October 1925.)

From the early days of the Republic to the dawn of the present century the principal roads of the United States were toll roads, or turnpikes. All persons using them paid for the privilege at the time of use. There were, of course, many roads of local importance only which were repaired with public funds or with tax labor, but these, in the main, were unsurfaced earth roads. Practically all roads improved by surfacing were financed by tolls collected either by companies or by units of government. So universal was this method that the verb *to turnpike*, coined from the noun which originally signified only the gate used to stop travelers on the toll roads, was used practically as a synonym for *to improve*.

Our people will never again submit to a method of collecting revenue for highway improvement which requires the traveler to halt on his journey and pay a toll as the price of proceeding. But because we do not pay for the use of the roads at the moment of use as we did in the turnpike days is no reason for assuming that we no longer pay for the roads.

No one who has followed the development of the gasoline tax as it has been adopted by one state after another until now when it is collected in 44 states and the District of Columbia; no one who has observed the tendency to increase the rate of this tax once it has been adopted; and certainly, no one who has paid the tax at the rate of 2, 3, or 4 cents for every gallon of gasoline consumed by an automobile or motor truck can be deluded into the belief that the use of the highways is free. The gasoline tax differs nowise in principle from the turnpike toll; and the motor-vehicle license fee as it is collected and applied is scarcely distinguishable from it. Together these two methods of taxation yielded in the United States a total of more than $300,000,000 in 1924, or more than the whole annual expenditure for highway improvement and maintenance in the entire country prior to 1919. This sum and an additional sum of $158,014,709 paid to the Federal Government as excise taxes on automobiles, motor trucks, and parts for these vehicles, were paid directly by the owners of motor vehicles into the public treasuries, and, with the exception of the latter, the payments were made for the privilege of owning and operating vehicles over the public roads. These motor-vehicle owners, moreover, now number upwards of 15,000,000 in all probability, and certainly they constitute, as a class, a large proportion of the tax-paying public which contributed last year the balance of the billion dollars of highway revenue that was not collected directly from them as motor-vehicle owners. The owners of motor trucks or commercial vehicles paid proportionately more than the average owner of a motor vehicle, since their license fees are higher than the fees charged for passenger cars in nearly all states and their consumption of gasoline is greater.

So when we speak of "free highways" for commercial vehicles we must be sure that our meaning is made perfectly clear. We cannot mean that the use of the highways is entirely free to any commercial vehicle. We mean merely that the owners of commercial vehicles, and especially those owners engaged in the business of transport as common carriers, do not themselves pay the entire cost of constructing and maintaining the highways they use out of their revenues as the railway companies pay for their tracks; and we imply, therefore, that the rates charged for the service of the vehicles are not based upon a complete payment for the use of the roads. Compared with other users of the highways, the owners of commercial vehicles pay a greater sum per vehicle for their use. It is only by comparison with the railways, if at all, that they may be said to enjoy a relatively free use.

Volume and Classification of Highway Traffic

It will be well at this point to look, first, into the usage of our highways, to see who is using them, what kinds of vehicles are operated over them and the relative numbers of each kind, what are the highway requirements of the various types of vehicles; and then to ascertain the sources from which funds are obtained for the building and repair of the highways.

Broadly speaking, we know that at the end of 1924 there were registered in the several states 17,591,981 motor vehicles of which 15,371,570 were passenger cars, 2,131,332 were motor trucks, and 89,079 were taxies, buses and cars for hire. These vehicles are operated over the rural highways and the city streets. It will be noted that the number of passenger cars is approximately seven times as great as the number of motor trucks, taxies, buses and cars for hire, but, from evidence obtained by the Bureau of Public Roads in its transportation surveys in several states, it ap-

pears probable that the utilization of the rural highways by passenger cars is more than seven times as great as the utilization by motor trucks. Comparing the operation of trucks and passenger cars it appears that a greaaer percentage of the operation of the former than of the latter is over city streets.

There are a number of evidences of this. For example, the Bureau's Maine survey showed that the traffic of trucks on the rural highways increased from 1916 to 1924 at a slower rate than the registration of trucks, while passenger-car traffic increased at a greater rate than passenger-car registration. The same survey showed an average daily utilization of the highways of the state, between July and November, 1924, amounting to 2,904,000 vehicle-miles for passenger cars and 283,000 vehicle-miles for motor trucks, a ratio of approximately 10 to 1, whereas the registration of the two classes of vehicles in the state was approximately as 6 to 1. Similar indications in other states in which intensive studies have been made confirm the conclusion that the relative utilization of the rural highways by passenger cars as compared with motor trucks is generally even greater than the ratio of the registration of the two classes of vehicles, and it is not far from the truth to say that the use of the highways by passenger vehicles is 10 times as great as their use by motor trucks.

This fact is adduced merely to show that improved highways are demanded for other purposes than for the operation of commercial vehicles, although it is patent without proof that there would be practically as great a demand for highway improvement as there is now if there were no motor trucks at all. However, since the fact has been brought out, it may be well to mention in passing that the records of the 29 states which segregate license receipts from passenger cars and motor trucks show that the motor trucks, which in those states constitute 13 per cent of the total number of trucks and passesger cars, pay 24 per cent of the total license receipts.

However, the point that must be made clear is that improved roads are needed and demanded by the owners of the more than 15,000,000 passenger cars, and a form of improvement adequate for these vehicles would be required even if there were no motor trucks or commercial vehicles. The passenger cars are so numerous that there is one for nearly every family in the United States. So long as the roads required for these vehicles are paid for by the public, therefore, it makes little difference whether the necessary revenues are raised by taxation levied upon the vehicles or upon any other basis. The cost in any case would be paid by practically the same group, since the owners of passenger cars constitute the great proportion of the tax-paying public. Moreover, it is indisputable that the owners of these vehicles should pay for the roads that they demand and require. The only point in question is whether the owners of commercial vehicles using roads for which they pay only in part are thereby subsidized to the extent that the public, or — almost synonymously — the whole group of motor-vehicle owners, assists in the payment; and whether these owners of commercial motor vehicles are thus given an unfair advantage in competition with the railways and other commercial carriers. That is what the problem comes down to.

Effect of Truck Traffic on Character of Road Improvements

Now, it is a fact that while the improvement of highways would be demanded on as great a scale as that which obtains if there were no motor trucks in existence, still the character of the improvement is influenced by the existence and operation of the trucks. Passenger cars with their human burden rarely exceed 3 tons in weight. The great majority weigh less than 2 tons. Practically all of them are equipped with pneumatic tires, and they travel at a customary maximum speed of about 35 miles an hour. The highest degree of improvement required by the passenger traffic therefore, is a road paved with the surface that will withstand the static load and impact of a 3-ton vehicle equipped with pneumatic tires, and smooth enough to be reasonably comfortable for travel at 35 miles an hour. As nearly as can be determined, this would call for the equivalent of a concrete pavement with an average thickness of 6 ins. Of course, I do not mean to say that a road of this character would necessarily be built wherever passenger automobiles are used. The extent of the maximum improvement naturally depends upon the occurrence of traffic of sufficient density to warant the necessary expenditure.

As to the motor trucks, their maximum weight is limited by law in all states, the restrictions varying from 8 to 15 tons. The trucks in use range from those which

have a carrying capacity of ½ ton up to those built to carry 7 tons. Very few trucks are in use which are designed to carry more than 7 tons and the number of 7-ton trucks is very small. On all roads the bulk of the motor-truck traffic is found to consist of vehicles having a carrying capacity of from ½ to 1½ tons; but nearly all roads are used occasionally by 5-ton trucks, and in certain sections, especially near the larger cities, such heavy trucks form a considerable percentage of the total traffic.

The truck traffic on the state highways of Connecticut may be taken as typical of the most severe condition that has to be met. That traffic, as shown by the state wide survey made by the Bureau of Public Roads, consists of the various sizes of trucks in the following percentages: ½ to 1½ tons, 64.7 per cent; 2 to 2½ tons, 14.3 per cent; 3 to 4 tons, 9.9 per cent; 5 to 5½ tons, 10:5 per cent; and 6½ to 7½ tons, 0.6 per cent. The tonnages refer to the carrying capacity of the vehicles, which average about 2 tons. The gross weight when fully loaded will, in each case, be more than twice the load capacity, except as limited by the state law which fixes a maximum limitation of 25,000 lbs. It will be seen, therefore, that in this state where truck traffic is as heavy as will generally be found anywhere, about 80 per cent of the vehicles will not exceed 6 tons in gross weight, and 90 per cent will not exceed 8 tons. Ten per cent of the total number may weigh as much as 10 tons and a few may equal and in rare cases exceed the maximum legal weight of 12½ tons. A considerable proportion of the lighter vehicles are equipped with pneumatic tires, but practically all of the heavier ones have solid rubber tires; and their speed rarely exceeds 25 or 30 miles an hour and generally is less.

A popular idea exists that such traffic is highly destructive and necessarily so. It was implanted in the public mind during the World War when roads which had been built for lighter vehicles were destroyed by the heavy trucks which were put into service by the Army. What happened is inevitable whenever a light-duty road or other structure is called upon to perform heavy duty.

Roads can be built to carry vehicles of any weight, heavy or light, and so long as the designed load is not exceeded there will be no destruction. Roads will wear out as steel rails, and motor trucks and rubber tires wear out. But they will not be destroyed; and whether the relatively heavy loads be few or many there will be no appreciable difference in the rate of wear.

The first essential is to fix the maximum vehicular weight. That has been done by law in all states. The next is to build the roads to carry the maximum load. That is being done. The third is to enforce the legal weight restrictions. Where these three essentials are properly observed, there will be no destruction; and the only appreciable result of an increase in the design load will be an increase in the cost of construction.

Additional Highway Costs Attributable to Truck Traffic

For such traffic as the Connecticut truck traffic described above, several types of pavement will give practically equal service. A suitably designed brick pavement, or bituminous concrete pavement, or a concrete surface might be used. For purposes of comparison it will be assumed that the choice is concrete. In that case a pavement 7 ins. thick at the center thickened to 9 ins. at the edges, would in all probability carry the traffic safely. The average thickness of such a pavement would be somewhat less than 8 ins.; but let us say that it would be 8 ins. Then, compared with the pavement required for dense passenger-car traffic only, such a pavement would have an extra thickness of about 2 ins. of concrete—an extra cost of, say, $10,000 a mile. Roughly, that is the measure of the additional cost of building for heavy-truck traffic.

Whether or not the additional cost is justified is a comparatively simple problem in economics. The use of heavy trucks is not imperative. Frieght can be moved over the highways in one-ton trucks, which are no heavier than the larger passenger cars. A large proportion of the tonnage in Connecticut and everywhere else is actually carried in such vehicles. But there is a very decided economy in the use of the larger units. Where there is a sufficient volume of freight to be moved and full loads can be provided for the heavier trucks, the cost of the haulage can be considerably reduced. Whether or not to build the road to accommodate the heavier vehicles is then simply a question of the number of such vehicles to be operated. If they are numerous enough, the combined savings in operating cost of the vehicles will more than offset the additional cost of the road and it will be economical to expend the larger sum for the road.

Obviously the employment of this method implies that only certain roads will be built as heavy-truck roads. That means a classification and building of roads according to duty; and it means also a restriction of heavy trucks to operation over heavy-duty roads. Such a classification is already in practical effect in those states where the traffic requires it; and the restriction of the heavy traffic presents no practical difficulty. It takes care of itself. Heavy trucks can be operated economically only between points at which they can take on a full load. Between such centers heavy-duty roads are generally justified by the traffic. It is rarely necessary to prohibit operation of the heavy trucks over by-roads, because there is rarely any occasion for the heavy trucks to turn into such roads. When the highways are properly classified, economic law accomplishes the restriction of the heavy traffic to the heavy-duty roads and leaves very little for statutory laws to regulate.

The Problem Restated

Summing up, then, I think it is evident that: (1) there would be a demand for improved roads whether commercial vehicles were operated over them or not; (2) as a general rule the passenger-car traffic is at least 10 times as great as the motor-truck traffic; (3) the roads required for the accommodation of the passenger-car traffic would be adequate for the transport of freight in one-ton trucks; (4) the use of larger units makes for more economical operation; (5) the heavy motor trucks do not destroy the roads that are built to accommodate them; and (6) if the construction of the roads is properly related to the character of the traffic, the operation of the heavier truck units produces savings which more than offset the greater cost of the roads.

Now, from what has already been said it must be apparent that if any commercial vehicles are receiving free highway service or even a service that is relatively free, it can be only those commercial vehicles which exceed in weight the passenger cars for which improved roads must be built whether trucks move or not. These heavy vehicles do necessitate the building of more costly highways than would otherwise be required. For this additional service they pay higher license fees than the lighter vehicles' fees, which in some cases run to more than $400 a year. But perhaps they do not pay enough, which is a supposition requiring careful analysis. At any rate no such contention will hold with respect to the light commercial vehicles which impose no greater burden upon the highways than the passenger cars. If these light commercial vehicles pay as much as the passenger cars of equal weight, they are paying as much as can reasonably be expected; and they do pay at least that much—all of them.

Sources of Highway Revenue

Before going into the question of whether or not the heavier trucks pay as much as they should, let us first obtain some idea of the manner in which the cost of the roads is being met. Unfortunately the latest reasonably exact statistics with regard to the revenue obtained from various sources are those collected by the Bureau of Public Roads for 1921. These will no longer serve our purpose because of the great increase in motor-vehicle revenue that has occurred since that time. However, it is reasonably certain that the total revenue is now no greater than it was in 1921; we have definite information with regard to the amount of the motor vehicle revenues; and a reasonably reliable estimate may be made of the other revenues. Table 1 presents data developed in this way for 1924 with the more exact 1921 statistics as a basis.

In this tabulation the motor vehicle is credited directly with the license fees that are paid for it and the taxes on the gasoline which it consumes. These two special taxes yield $300,000,000, or one-third of the total highway revenue. But in addition to these direct taxes other taxes were paid on account of the motor vehicle, which do not appear here to its credit. For example, there are the federal excise taxes which in 1924 amounted to $158,014,709, and which, since the tax was first levied in 1918, have produced more than twice as much revenue for the Federal Government as has been spent for federal-aid and forest roads. There are also the wheel taxes paid in some states; and the very considerable though incalculable, property taxes, paid on the vehicles themselves and on the manufacturing plants, garages, agencies, and service stations which owe their existence to the use of the vehicles. Add all these taxes paid directly or indirectly on account of the motor vehicles and the total will certainly exceed $500,000,000 for 1924, or more than half the highway revenue for the year, as shown in Table I.

Bear in mind that these are the taxes paid on account of the motor vehicle! Then recall that there are probably more

TABLE I. APPROXIMATE HIGHWAY REVENUE, 1924

(Exclusive of bonds)

Federal-aid and forest road funds	$ 90,000,000*
Property taxes	415,000,000
Motor-vehicle license fees	225,000,000
Gasoline taxes	75,000,000
Miscellaneous taxes	95,000,000
Approximate total revenue derived by taxation	$900,000,000

*This is the approximate expenditure during the year. As there are no federal taxes especially levied for road purposes, it is assumed that an amount of the total taxes equal to the road expenditure is raised for that purpose.

than $15,000,000 motor-vehicle owners in the United States with a total population of 112,000,000, and it will be clear that the owners of motor vehicles, as previously remarked, constitute a very large percentage of the tax-paying class, and hence pay a large proportion of the highway tax that is not taken from them directly or indirectly on account of the motor vehicles. All of which means that already the improved roads of this country are being paid for in very large part by the owners of motor vehicles.

With this explanation, the statement that the owner of a light commercial vehicle is paying as much as can be expected when he pays at least as much toward the cost of constructing and maintaining the highways as the owner of a passenger car of equal weight, will readily receive credence.

Highway Costs Borne by Owners of Heavy Vehicles

But what of the owners of the heavier vehicles? Are they paying sufficiently for the special road service they require? It is evident that they are paying some amount in the form of license fees, some more in gasoline taxes, more still in federal excise taxes, still more in property taxes on their trucks and garages, and over and above all this the general property taxes which they pay along with all other property owners. Certainly they are paying something for their use of the roads. Their highway service is certainly not free; but do they pay enough?

This much can be said at once: They pay much more than they did ten years ago. In 1914 the average license fee paid by owners of heavy trucks was but little higher than the fees paid by owners of passenger cars. In that year the average fee paid for a 1½-ton truck was only $6.43. In 1924 the average fee paid for the same size of truck was $31.15. For a 3½-ton truck in 1914 the average fee was $8.36; in 1924 it was $85.75. In other words, the 1924 fees for 1½-ton trucks were 485 per cent of the 1914 fees; those for the 3½-ton trucks were ten times as great as they were ten years previously.

But the fees paid by owners of 5-ton trucks increased much more than either of these. The average truck of this size in 1914 paid only $8.80 a year for its license to operate. Last year the average fee for the same size truck was $139.39, an increase of 1,500 per cent. In one state the fee for a truck of this size was over $400 a year; in three other states the license to operate cost more than $300; in four states the charge was between $200 and $300.

Clearly these heavier trucks were not sufficiently charged for their use of the roads in 1914; perhaps they are not paying enough now; but certainly they are paying a very considerable amount.

According to the registration statistics for 1924 there were 1,384,620 trucks of all sizes in the 29 states which classify their license receipts so that the amounts received from passenger cars and trucks can be segregated. These trucks paid license fees totaling $29,211,455, or an average of $21.10 per truck. In the same 29 states the 9,107,145 passenger cars registered paid $93,269,181, or an average of $10.24 per car. Taking all sizes of trucks together, it will be seen from these figures that the average truck paid in license fees more than twice as much as the average passenger car. It is not possible from available records to compare their gasoline taxes; but if it were, we should probably find a somewhat similar ratio.

In arriving at this average truck fee of $21.10, however, we have included all sizes of trucks, the small with the large. Judging by the percentages of the various sizes of trucks manufactured, it is probable that about 80 per cent of the vehicles included are trucks of the capacity of one ton or less. The fees paid by these vehicles probably do not exceed on the average the fees paid by the passenger vehicles; and, for reasons previously mentioned, there is no need that they should. Assuming that these vehicles which constitute 80 per cent of the total number of trucks pay exactly as much as the passenger cars, that is, $10.24, it follows that the remaining 20 per cent of all motor trucks which have a gross weight of more than 3 tons pay an average fee of not less than $64.50 or about 6.3 times as much as the light trucks. If this judg-

ment be correct, and it cannot be far wrong, then the 20 per cent of all trucks which have a gross weight in excess of 3 tons pay at least 60 per cent of the total license fees paid by all trucks.

Let us see what this percentage would amount to in dollars and cents for 1924. As previously stated, the $29,211,455 of motor-truck license fees received by 29 states were paid by 1,384,620 motor trucks. The total number of motor trucks registered was 2,131,332. Assuming that the fees paid by the trucks in the other 19 states and the District of Columbia average as much per truck as in the 29 states for which we have definite figures, it appears that the total of all license fees paid in 1924 by all trucks in the United States could not have been far from $45,000,000. And if 60 per cent of this sum was paid by trucks of capacity in excess of 3 tons, it follows that these trucks probably paid at least $25,000,000 in license fees alone for their use of the roads. Whatever sums their owners pay in gasoline taxes, in excise taxes, and in property taxes on their trucks and garages would constitute an addition to this sum.

Now, it has been assumed that the construction of roads to accommodate these vehicles should add a maximum of $10,000 a mile to the cost of the roads they use. If it be assumed that the life of such roads will be 20 years, then the $25,000,000 paid in license fees is sufficient to pay $10,000 a mile and interest at 5 per cent on 33,000 miles of high-type pavement; and according to the best available estimates there are not more than 46,000 miles of such pavement in the United States. In this calculation the license fees only are considered. If the other taxes paid by the heavy trucks were included, it is probable that the total would be found to be sufficient to pay the additional cost of $10,000 for the entire mileage. Certainly, it appears that these heavier commercial vehicles now pay a very considerable sum for their use of the highways.

Comparative Highway Expenses of Motor and Rail Transport

Let us examine the matter from another angle. As previously suggested, the question of the free or relatively free use of the highways by commercial motor vehicles is usually raised only when their operation is compared with that of other commercial carriers, especially the railways. It is claimed that the railway compasies must, perforce, build and maintain their own tracks out of the revenues accruing from their operation, whereas the commercial motor trucks, using the public highways, have their roadway provided for them, and enjoy therefore, considerable advantage in competition with the railways. As we have already seen, the commercial vehicles really do not enjoy absolutely free use of the highways, but, on the contrary, pay very considerable sums for such use. Nevertheless, are these sums still so small that motor transport has a competitive advantage over railways? Suppose now that we examine the relative payments for roadways made by the commercial motor vehicles and a typical steam railway system.

It has already been shown that the average license fee paid by all motor trucks in 1924 was $21.10 per truck. According to the National Automobile Chamber of Commerce the percenteages of the various sizes of trucks manufactured in 1924, rated according to capacity, were as follows: ¾-ton and less, 10.8 per cent; 1-ton 71.4 per cent; 1½-ton, 7.7 per cent; 2-ton, 2.2 per cent; 2½-ton, 3.8 per cent; 3½-ton, 1.0 per cent; 5-ton, 1.8 per cent; and over 5-ton, 1.3 per cent. Assuming that these percentages apply approximately for all trucks in use, it appears that the capacity of the average truck is about 1¼ tons. Therefore, it may be assumed that the average motor-truck license fee is about $16.90 per ton of capacity.

According to the annual report of the Baltimore and Ohio Railroad Company for the calendar year 1924, that company paid from its revenue during the year a total of $26,638,363.05 for maintenance of way and structures. The same report states that in the company's equipment there were 100,092 freight cars and 1,441 passenger cars. The freight revenues were more than six times as great as the passenger revenues. Let us consider, therefore, that the entire cost of maintenance of way and structures was paid by the freight business. Assuming then, that the capacity of the 100,092 freight cars averages 40 tons per car, we find that the draft upon the company's revenues for maintenance of way and structures was only $6.65 per ton of freight-car capacity, or more than $10 per ton less than the commercial motor trucks paid in license fees alone for the use of the highways.

On the basis of the above computations, therefore, the commercial motor vehicles not only pay a very considerable sum for their use of the highways, but also, on the average, they actually pay

much more per ton of capacity than a typical well-kept railway sets aside from its earnings for the maintenance of its track and structures.

Relative Proportions of Operating Income for Way Expenses

However, there is another aspect to be considered. The owners of motor trucks may pay a very considerable sum for the use of the highways, and they may pay for that use a greater amount on a capacity basis than the railways pay for their tracks, but do they pay into the public treasuries for the construction and maintenance of the roads a fair percentage of the income derived from the operation of their trucks?

In attempting to answer this question we must take into account the character of the highway service that the commercial-vehicle operators receive. A railway's tracks are generally maintained in a condition uniformly adequate for its traffic. The commercial motor-vehicle operators, on the other hand, have no such uniformly adequate highways to deal with in many of the states; and where the highway service is inadequate it is not to be expected that they will be willing to pay as great a proportion of their income as the railways pay for their tracks.

A number of the states, however, do offer fairly adequate highway service, and among these is the state of Connecticut. It happens that a good deal of information about the motor-truck traffic of that state has been gained from a comprehensive survey; so we shall take it as an example.

On the basis of the Connecticut survey made by the Bureau of Public Roads, it was estimated that the net volume of motor freight transported over the state road system between September, 1922, and September, 1923, was approximately 88,000,000 ton-miles.

At that time there were 29,140 motor trucks registered in the state. How many of these trucks made use of the rural highways and contributed to the total movement noted above it is, of course, impossible to say. Naturally some of them were operated in the cities exclusively. For our present purposes it is not necessary to know the exact volume of city or rural traffic. The fact remains that the owners of all these vehicles were taxed for the maintenance of the state highways whether they used them or not; and, as a group, they paid in registration fees only, according to the Bureau's records, $956,368.93. They paid, also, some additional sum in the form of permits and licenses; how much can only be estimated. The 29,140 motor trucks and the 148,791 passenger cars registered during the year paid between them, in the form of such licenses and permits, a total of $1,070,909. If we assume that the motor trucks paid only in proportion to their numbers (a conservative assumption), then the motor-truck share would be approximately $200,000. Adding this amount to the sum paid as registration fees we find that they paid in both ways not less than $1,150,000, and there is still to be added the amount they paid in the form of gasoline taxes. Here again it is impossible to state exactly how much was paid by the motor trucks. The total tax collected from all motor vehicles, including automobiles and trucks, was $880,222.70. If we again assume that the motor trucks paid only in proportion to their numbers (which is again a very conservative estimate) we must credit them with a payment of not less than $140,000, and this added to the amount paid in other ways would bring their total contribution to the state up to not less than $1,290,000.

This entire sum was paid into the state treasury by the motor trucks alone and all of it, under the laws of the state, was applicable to the construction and maintenance of the state roads. The excise taxes paid to the United States for new trucks and parts purchased during the year are not included, although these taxes also constitute a payment made by truck operators as a class, and in a sense may be said to be devoted to road improvement since they are paid into the United States Treasury from which are paid out the funds appropriated by the government for federal aid.

At the very least, therefore, the motor-truck owners of the state of Connecticut may be said to have paid toward the construction and maintenance of the state roads in 1923 the sum of $1,290,000; and in return they received the benefits of highway service for a total movement of 88,000.000 ton-miles. It seems fair to say, therefore, that these owners paid for their use of the state highways at the rate of approximately 1.5 cts. per ton-mile.

How much this movement may be said to have been worth to the truck owners can only be estimated. The bulk of it consisted of a movement of commodities in trucks owned by the shippers. A smaller portion was moved by commercial truckers. The rates charged for this latter portion would undoubtedly vary

widely with the length of haul and the character and value of the commodities hauled. Investigation shows, however, that the rates charged by commercial haulers in various sections of the country range between the approximate limits of 10 and 20 cts. per ton-mile; and a rate of 15 cts. would appear to be reasonable as an average. If, then, we assume the entire Connecticut movement to have been handled by commercial truckers at the average rate of 15 cts. per ton-mile, the ratio of the tax paid for the use of the roads to the gross operating revenue would be approximately 10 per cent.

Whether or not this is a fair percentage may be reasonably determined by comparison with the practice of the railways; and it is interesting to note that during the 12-year period from 1911 to 1922 the average amount charged by the railways for maintenance of way and structures was 13.3 per cent of their total operating income. Judged by railway standards, therefore, it would seem that, in Connecticut at least, the contribution of the motor trucks toward the maintenance of the state highways was reasonably adequate.

In this analysis we have credited to the support of the highways the entire amount of the taxes of various kinds paid by all trucks registered in the state into the state treasury, whereas it is apparent that much of the haulage of these trucks must have been over city streets. But the fact remains that all truck owners, whether they used the state roads or not, paid for highway upkeep; and it seems a fair presumption that they paid for the use of the city streets their full share of the taxes levied by the municipalities for street construction and repair.

Highway Expenses of Truck Owners in Other States

It is true that registration fees for motor trucks were higher in Connecticut in 1923 than in any other state. For the 25 states which segregated the fees received from motor trucks and automobiles, the average in that year was $18.23 per motor truck as compared with an average of $32.82 for Connecticut. On the other hand, the average capacity of motor trucks in this state was doubtless higher than the average for the United States, and the Connecticut gasoline tax was only 1 ct. per gallon, which was less than the tax charged by 27 of the 35 states then levying gasoline taxes. Fifteen of those 27 states levied a tax of 2 cts. per gallon; two charged 2½ cts.; nine collected a 3-ct. tax; and one a tax of 4 cts. per gallon.

Moreover, although the majority of the states received a smaller contribution from motor trucks, few other states provided highway facilities the equal of those of Connecticut. If, therefore, the motor truck owners in this state paid a greater amount than the average for the use of the state highways, on the other hand the majority of states that received less gave less in return.

All these considerations indicate definitely that commercial-vehicle operators not only do not receive free highway service, but that they pay for the service they receive at a relatively higher rate per unit of capacity than the railways pay for their way and structures. Also, in states where the character of roads that trucks have to operate over will justify it, the owners pay out of their earnings almost as great a percentage as the railways. It might be said that the contributions of truck owners to the highway program go partly toward additions to the capital investment, whereas the railway expenditures used for comparison represent maintenance or renewal charges rather than capital additions. It is recognized that the expenditures of the railways for maintenance of way and structures do not include interest on the capital invested in the track and other expenditures on account of the track. But, on the other hand, the truck fees and taxes used for comparison do not include property taxes on the trucks, garages, and shops which in some states exceed the combined license fees and gasoline taxes and which would not be paid but for the existence of the trucks; nor do they include the federal excise taxes collected on the trucks and their tires and other accessories.

Subsidizing of Motor Transport Is a Popular Fallacy

The comparisons with the railways have been made largely because popular opinion seems to hold that the supposedly free highway service enjoyed by commercial motor vehicles gives them an unfair advantage over the railways and enables their owners to establish such low rates for transport that business, properly the due of the rail carriers, is diverted. It has been shown that this belief is wrong in so far as it presupposes a free highway service for the commercial motor vehicles. It may also be shown from the evidence gathered in highway transportation surveys by the Bureau of Public Roads that it is wrong in several pre-

sumptions upon which it is founded.

The first of these is that the commercial motor trucks come largely into competition with the railways. The surveys show definitely that the competitive field is very narrow. In the main, the motor trucks are engaged in a service of distribution to and from railways, in short hauls which are unprofitable to the railways, and in the extension of transport service into areas not served by the railways.

The second presumption is that the commercial vehicles are operated largely as common carriers, but by persons and industries for the shipment of their own commodities, so-called owner-operators. We find, moreover, that there is every likelihood that the proportion of common carriers will remain low. Those individuals and companies which have thus far engaged in the motor transport business as common carriers have found profits to be low instead of high, so low in many cases that they have been forced to suspend operations.

The third presumption is that the motor-vehicle operators by virtue of their use of the public highways are able to establish rates which are lower than the rail rates and in that way take business from the railways. For this presumption also no reasonable foundation in fact appears. We find that motor-truck rates seldom, if ever, are lower than the corresponding rail rates. Generally they are slightly higher; and the business which the common-carrier trucks get comes to them largely because they offer direct and prompt service and, in some cases, because goods can be shipped safely by truck with less crating and packing than by railways.

Is Truck Competition Responsible for Abandonment of Rail Service?

But, it may be asked, if all this is true, then what is the reason for the large mileage of track abandoned by the railways? Since 1916 the railways have abandoned more than 3,800 miles of track; what is the reason for that abandonment? The Bureau of Public Roads has looked into that question, and finds that just 4.3 per cent of the mileage abandoned since 1920 can properly be attributed to highway competition. The Transportation Act, passed in that year, required all railways desiring to abandon trackage to secure certificates of public convenience and necessity from the Interstate Commerce Commission. The facts involved in all abandonments since then are fully set forth in the published opinions of the Commission, and are therefore available for analysis. Of the 2,439 miles abandoned and thus explained, 4.3 per cent was given up because of highway competition. Nearly 58 per cent was mine and logging trackage abandoned on account of the exhaustion of the natural resources for the exploitation of which it was constructed. Almost 30 per cent was brought about by the competition of other railways; 1.3 per cent was the result of the rearrangement of lines; and 7.3 per cent was due to other miscellaneous causes.

In the light of the facts revealed by these investigations we have come to the conclusion that the various taxes levied upon commercial motor vehicles are not unduly low and that they are in no substantial sense subsidized to the disadvantage of any other commercial carrier.

THE CONTRACTOR'S OWN PROBLEM

By W. F. Creighton, President, Foster and Creighton Co., Nashville, Tenn.

From remarks by Mr. Creighton in opening the session of the Constructors Section, American Road Builders' Association, January 13, 1926.)

Never in the past 20 years has competition been so keen as at present. The reason for this I believe is plain. We are in the same position as many other industries, in that there is more production than demand. The extraordinarily large volume of work during and since the war created an increased number of contractors; and now that the volume of work is getting back to normal they resemble a pack of hungry timber wolves. This is especially true of road building, which seems so simple, that many novices are tempted to try it and fall. They usually get thrown. At a Tennessee letting recently, about 20 projects were let, aggregating one and a half million dollars and nearly 500 bids were received. The same condition exists in Alabama and Florida.

It requires only a little thought to impress one that this condition cannot last long, but only until the "top waters" go broke or quit.

The next question to answer, is how shall the responsible contractor weather this storm. We must have work, and to meet competition at this time, must figure a small margin of profit.

The answer is first, in the language of the street, "Know your stuff" and as Ring Lardner would say: "Use the old bean."

We must get the highest efficiency out of men and equipment; we must study material costs early and late; we must cut off all dead wood, and eliminate every penny of waste. How this may be done in some instances is the object of this program. We must keep in close touch with the latest discoveries of the various laboratories, studying the material we use; and our competitors' jobs, to glean every point that would enable us to improve methods.

I listened, with some impatience, yesterday to a half expressed belief that engineers should help us by eliminating the irresponsible bidder, that they should even check up our bids, and if we are too low, give it to the next bidder; that the public should recognize our ability and give us preference. Gentlemen, this is not the rule of business, and it is hopeless to expect such help. We must help ourselves. What I wish to impress on you, and I wish I had the eloquence of some of our southern orators to do it properly, is that prices are low, but I believe are as high as we will ever see them, and the firm who continues in this business must mix a large portion of brains in it.

The next question facing us, but one that the engineers are more responsible than we for solution, is to determine what is wrong with concrete.

Those of us who have been mixing it for 20 years realize that we are not nearly so confident of results as we were when we first started. Some slight forward steps have been made by the Bureau of Standards, the Lewis Institute, and other investigators; but even now, neither chemists nor physicists know what takes place when cement sets; and the wise engineers are beginning to realize that "concrete" is not a mere mixture of cement, water and aggregate.

Our interest is, in this problem, of course, self protection; because as many of us know, we are blamed for failure, even when our actions are entirely governed by specification and inspection.

ONE-SIDED CLAUSES IN PUBLIC WORKS SPECIFICATIONS

By Gen. R. C. Marshall, Jr., General Manager of Associated General Contractors of America, Washington, D. C.

The opinion of contractors concerning many of the contracts that they sign is so generally known that it needs no repetition; yet in all the discussions of this subject to which I have listened the primary cause of their complaint seems to have been misconstrued. This is probably due in considerable degree to a careless use of the term unfair, whereas the provisions commonly criticized are scored on the grounds of ambiguity or the injection of unnecessary hazard and indeterminate elements of cost.

While there are instances in which a public department or private owner, usually assisted by legal counsel, has not hesitated to deal to contractors from the bottom of the pack, these cases should not reflect upon the great majority of engineers whose instinct is to deal fairly. It is but natural that frequent use of the word unfair has annoyed the engineering profession considerably in discussion of its contracts, and has succeeded in beclouding the effect of certain contract provisions on cost and business management. Probably the best thing that can happen for all elements concerned in this important matter of contracts, is to forget the term unfair and to investigate more carefully a few economic principles which the construction industry generally seems to have overlooked.

Before touching specifically upon the effects of certain contract provisions in common use, I should like to mention briefly what appears to be one reason for their apparently haphazard development and the reason also for much unnecessary friction and conflict within the industry.

Although construction is probably the oldest as well as the largest industry next to agriculture and carries almost as great a responsibility for the nation's well being, economists as well as those directly interested have developed little data on its special economic problems. Only since the war, has it been recognized as an industry whose business cycle wields a mighty influence toward the stabilization of other industries when those industries are floundering in a general business depression.

In spite of its annual output of between five and eight billion dollars, about the only time that this industry has moved into focal range of the press or the public has been when it served as a political foot ball or hatched out one of its scandals. Even at these times, it has received but little analytical study except from the angle of political expediency. Its problems and practices have generally been dismissed from the public mind, and in fact often from the engineering mind, with the assumption that the business of construction is a black sheep and never

can change its color. Such impressions are due almost entirely to ignorance of the business end of this industry and one of those factors which have contributed to its delinquency.

I have never seen a book on construction economics or administration that would give the young engineer an insight into the business intricacies of the industry with which he must deal or which would point out to him those basic principles of economics which are so essential to his successful administration of construction contracts. Our technical libraries are loaded with volumes on design which are of course indispensable to that minority which becomes technicians; but for the majority of young engineers who eventually move into executive or administrative positions, the library shelves are bare. Since many of them go either directly or eventually into a construction organization, this matter is of concern to contractors as well as to the professions.

Though the lack of necessary training may be due directly to the failure of engineering faculties to perceive the need of the engineering professions and the construction business, one cannot help feel that the major fault has been with these two elements themselves. In so far as I know they have never crystallized their opinions and given to the universities the benefits of an authoritative expression of their needs. It appears also that the engineering profession itself has not kept abreast with the economics of the construction industry or that it generally realizes how inseperably it is linked with the other elements in the responsibility for proper development of methods and trade practices and for the cost of construction. By this I do not mean to imply that contractors, manufacturers, dealers and the bonding companies have kept abreast, for we all seem guilty of the charge of gross neglect. What I do mean to impress, though, is that no one element of the many who are concerned in construction can clean the Aegean Stable of this industry without assistance.

From the general contractors point of view, the industry has what might be called three pernicious triplets, all of which are in need of expert attention. They are the lien law, the bond situation and day labor. None of their afflictions was brought on by responsible contractors and they cannot be cured by his hand alone.

A well known engineer said not long ago that as soon as the responsible contractors of the country got rid of the irresponsible contractors in the industry, he would like to adopt arbitration. But with the lien law and the surety bond establishing automatic credit for any man who desires to call himself a general contractor, it is likely that we will not obtain arbitration under that engineer for a long time.

Another engineer out in the northwest told the President of our Association that if the surety companies did not stop bonding irresponsible concerns his department would be forced to resort to day labor. Obviously these things are a matter of concern to all elements of the industry.

A short time ago the material dealers' national association adopted a resolution that all cement should be distributed 100 per cent through dealers, thus implying that wholesale prices to the public bodies and other large purchasers should be discontinued. In other words, the dealer should obtain a commission on any cement used in his locality whether it passes through his hands or not. These are a few of the many conditions to which everyone who lives by the construction industry should give some thought. There are many others, also, in which we all can well afford to take an interest.

To revert back to the question of contracts, it seems to me that as long as the work under a specified contract is clearly defined and the parties to the contract are of one mind as to what shall be done and how it shall be paid for, the question of fairness ceases to exist. The trouble is that this condition does not obtain on far too many construction contracts.

State highway specifications usually set up an estimate of quantities by which the contractor determines his overhead costs and to which at so much per unit these costs must be distributed. If some of the units are omitted, the overhead assigned to them is left uncovered and stands as an uncompensated expense of the work. Yet most specifications provide that the Department without making any adjustment whatever, has the right to increase or diminish these quantities or leave out any portion of them altogether. Obviously a material reduction of quantities or even an extension of the work if prices are rising, changes the actual unit cost of the work. Thus the contractor builds something different from what he was led to believe he would build and in effect the original basis of the contract is altered; this the courts have so held repeatedly where increase or decrease of

quantities is excessive, and it may be added more than ten per cent may often be interpreted as excessive.

There is no question but what these changes must be made on occasion, and some proper provision therefor should be included in the contract, otherwise the bidder can protect himself only by charging his overhead to those units most likely to remain constant, thus usbalancing his bid, or by adding an item of contingent expense in his estimate. Since changes must be made, since court interpretation of these unlimited right of change clauses is quite clear and since they add an item of cost to the work, it might be well to eliminate them in favor of a more scientific provision. In a few contracts this question has been handled by giving the department a right to change the quantity of the work up to say five per cent without change of price, and by having the bidder state unit prices in his proposal for other percentages of change. This plan I am advised has been tried successfully by a number of engineers.

The effect of so-called drastic contract provisions upon the actual cost of a construction project does not seem to be very generally appreciated. By a drastic clause is not meant one which provides swift and sure penalty for violation of contract, but one which makes impossible an actual estimate of cost, which tends to conceal elements of cost from a bidder, or which makes acceptance of the other contracting party's opinion a condition precedent to payment. These clauses appear to have grown out of a perfectly natural desire of the owner and his representa tives to be protected against every possibility of loss until their project is delivered complete and unencumbered.

No one can justly blame them for wanting this protection, but it should be apparent that this assurance in connection with a construction project, dependent as it is upon so many uncertain factors, actually involves a significant item of cost. When a contractor guarantees a structure against acts of God, and all other contingencies of construction, he has underwritten about the worst risk to be found in industry. No insurance company will underwrite it and he must carry it himself.

Some of these hazards can be more cheaply assumed by the owner than the contractor and the insurance premium eliminated from the cost of construction. I presume that one reason why this is not generally done is that we have always with us a supply of individuals who will gamble at anything and frequently the owner can find a bidder who attempts to conduct an insurance business without collecting a premium.

In general these so-called drastic provisions affect the cost of construction in three ways.

First, by introducing hazards or uncertainty of requirements which the construction company can not estimate and must therefore be covered by a contingency charge. Second, by restricting competition. Third, by actually increasing the cost of operations through specifying unattainable perfection or increasing the financing charges of the work by heavy retainages or delayed payment. A few examples will serve to show that the effects mentioned are real and not illusionary. As a clear example of introducing unnecessary hazard a quotation from the general conditions of the standard contract of the American Railway Engineering Association will serve. This clause states that:

"Should any work or material be required, which is not denoted in the specifications or plans, either directly or indirectly, but which is nevertheless necessary for the proper carrying out of the intent thereof, the contractor is to understand the same to be implied and required and shall perform all such work and furnish any such material as fully as if they were particularly delineated or described."

Another good example found in various state highway contracts reads as follows:

"The engineer may, by written notice to that effect, suspend all or any portion of the work if, in his judgment, the same cannot be properly done for any reason beyond the control of the contractor, but no allowance of any kind will be made for such suspension except an extension of time for the completion of work."

These clauses and others of similar nature are accompanied by a clause giving the engineer (in effect one party to the contract) final decision in all matters of disagreement. The possibility of extra cost which cannot be foreseen or estimated by the construction company under such provisions is obvious. Of course where it is possible to sue the state, and the amount of money involved is sufficient to warrant legal action, the contractor can recover in spite of this clause if he has sufficient cause. But some states cannot be sued. Often the amount involved would merely pay the attorney's fees and consequently the construction

company charges it up to profit and loss. Any contractor who does not put in his bid some sort of a contingency allowance for these provisions, is ignoring the most elementary principle of sound business.

It is difficult for a bidder who knows his operating costs, and knows also the cost of insuring owners against acts of God and other contingencies, to believe that the clauses here mentioned are not a premeditated effort to get something for nothing. In a measure perhaps they are —not that a department expects to get units of work without cost, but that it seeks a protection which should be underwritten by Lloyds of London, yet fails to perceive that premiums therefor must be charged as an element of cost.

A tendency of this condition has been to make of construction too much a battle of wits and not enough the rendering of service under reasonable hazard at a reasonable profit. Forty per cent of the corporations engaged in construction in 1923 made no net income, according to the income tax department, and for those who made a profit the average was about 2.1 per cent. This condition, which is due greatly to excessive hazards, benefits neither the industry nor the public.

On occasion the insurance premium to cover contingencies may be forgotten or crowded out of an estimate by ignorant bidding, but there has yet been devised no way whereby a department can recover the loss occasioned by inadequate competition. Competition may be lost either by making contracts too drastic or by using clauses which make it impossible for many bidders to undertake the contract.

I have no specific contract to quote in this instance though I have seen many of them which automatically reduced the number of bidders. This can be done by requiring commencement of the work within specified time. I know of a certain project on the Mississippi river where such a provision stipulating 30 days eliminated all of the contractors on the west coast, some of whom were anxious to bid on the project.

When a contract contains a date of completion with penalty, the date of commencement is of little practical value. In the first place commencement may be superficial yet legal and in the second place, it is practically impossible to determine when work is actually commenced. Assuming that commencement can be clearly defined and determined, there is still the possibility that the limit set will exclude any bidder however suitable, who cannot release equipment on some other project for 35, 60 or 90 days. A more rational procedure would be to eliminate the date of commencement and hold to the necessary rate of progress for a specified date of completion.

Probably the most outstanding effect on cost to be noted, is that of increasing the direct construction expense. An example from the Federal Government will show how this occurs. One of the Departments had a project, estimated to cost about two million dollars and after extensive advertising, they received but two proposals. As his department had signified its intention of departing from day labor, the Associated General Contractors exerted its efforts to interest contractors all over the western states in this project. Many of them said that they would bid unless the contract form was found to contain a joker.

Unfortunately the contract did contain a joker, which prevented many firms from submittting a proposal. The trouble was in the payment clauses. An analysis which one of the companies gave to me indicated that by reason of terms of payment, it would be necessary for a contractor to have something like eight hundred thousand dollars of his own money tied up in this two million dollar project before it was completed. These provisions automatically eliminated a great number of bidders who could have handled the project satisfactorily under usual terms of payment. Not only that, but the clauses used injected into the work an unnecessarily heavy item of interest.

Some of the State Highway Specifications hold back fifteen and twenty per cent as a retainer, which merely adds an unnecessary item of interest and reduces the number of marginal bidders capable of handling the project. I do not say that this always reduces the number who think they are capable of handling the project, because hope springs eternal in the contractor, and the more inexperienced he is, the further it springs.

Heavy retainages seem to be of little practical value, since they are not large at a time when a dishonest concern is most apt to default, and often brings on default by increasing the financing problem of the contractor at a time when his other difficulties are at a maximum. The policy of reducing the retainage when the job is half done, or of making progressive reduction when it progresses satisfactorily, has I believe been thoroughly justi-

fied by the experience of those departments that have tried it.

In any discussion of contracts it is difficult to keep from drifting more or less deeply into the matter of arbitration, as it affects vitally the attitude of the contracting parties toward each other as well as the character of construction service. I will not go deeply into the pros and cons, but I hope that all parties concerned in the construction industry will give this subject more analytical study in the future, as it offers great possibilities in removing much of the friction encountered by the various elements of industry in their transactions with each other.

In our office are on file a great many sub-contract forms used by members of the Associated General Contractors, practically all of which contain an arbitration clause. This clause was not put in at the instance of sub-contractors who demanded a means of impartial determination, but was put in by the general contractors themselves, who realized the benefits to both parties. It is possible that the engineering profession like architectural professions and contractors will upon further study arrive at the same conclusion.

Construction is, I believe, the only industry in the United States wherein the purchaser is generally opposed to arbitration. This may or may not be significant, but I believe it is one indication of why the construction industry is struggling with business practices and economic problems that have long ago been solved by other industries. Those industries have ceased to debate as to whether an arbitration clause between buyer and seller is advisable and have turned their attention to the necessary means of enforcing arbitration awards where such means are not already provided by law.

At the last session of Congress, a federal law was enacted to make enforceable written agreements to arbitrate disputes arising out of contracts, maritime transactions or commerce among the states or with foreign nations. Similar laws suitable to state needs have been passed by New York, New Jersey, Oregon and Massachusetts, with other states likely to follow.

In the discussions of arbitration that have come to my attention, it seems to have been assumed that the agreement to arbitrate is something which acts purely in favor of the general contractor and is something that the other party to the contract more or less gives him as a present. No conception could be further from the actual truth. Arbitration when properly written into a contract gives the contractor nothing that it does not give the owner and it strengthens immeasurably the hand of the engineer.

I believe there is no greater evidence of the need of arbitration than that given by the enormous record of law suits in construction.

In a vast majority of these, the decision has favored the contractor. Often the contractor has won on a technicality that would never have been countenanced by an arbitration board drawn from within the industry. The man who is acting in bad faith will invariably seek the court with competent counsel in preference to seeking arbitration.

These points, however, do not represent in the judgment of those who have tried it most thoroughly, the principal value of an arbitration clause. The American Institute of Architects has long used such a clause in its standard contract and would not think of doing otherwise. Its representatives on the Joint Conference on Standard Construction Contracts indicated that the Institute would not participate in the Conference if it proposed to draw up a contract form without provision for arbitration. This they considered a backward step which would have destroyed the work done within their society throughout nearly a generation.

The form of arbitration contained in the Conference Document and that which is most widely favored gives the engineer full authority as to the result to be produced and the same control of the work that he has always had and merely provides that disputes involving extension of time or compensation in accordance with the terms of the contract shall be settled by agreement or arbitration. The greatest value of such a provision is not in its actual exercise to determine monetary awards, but in its effect upon the attitude of the contracting parties. Its chief influence is to prevent the assumption of hasty or abitrary stands from which neither party will willingly retract, and to bring about agreements which are mutually satisfactory without resort to legal action. The representatives of the American Institute stated before the Joint Conference that in their opinion, it not only eliminated in most cases the need of litigation but also the need for arbitration itself.

On the contracting side of the fence, we look forward hopefully to the establishment, not only of arbitration, but also

more standardized contracts in general, which will gradually build up a sound and enforceable code of contracting practice. We believe they will facilitate interstate competition, decrease disputes and litigation and tend to make it more difficult for any dishonest concern to continue operations.

Before concluding, I should like to emphasize one other point which concerns yet transcends the subject of contracts.

As one considers the record of defaulted contracts, particularly in highway work, it seems very likely that both engineers and contractors have not perceived the limitations of a legal contract. By this I mean there seems to be a feeling that if a contract is sufficiently airtight for one party or the other, that party has protected itself in every possible way. Yet if we consider the matter carefully we realize that no form of contract can produce a high grade of work and honest performance from a low grade contractor who is dishonest.

Instances are innumerable where projects have been awarded to contractors with full knowledge that they could not perform the work satisfactorily and would eventually default. The evils of such procedure and the trouble it has caused from one end of the country to the other are too generally known to bear repetition. It is a procedure which no sane man would follow in buying a suit of clothes.

This is not offered as a criticism of engineers, because we all know what the engineer in charge of public construction is up against in awarding contracts. Until he receives sufficient support from the responsible element of every group concerned in construction and until these groups make it their business to see that the engineer with the courage of his conviction is not made the victim of political expediency, they must suffer the consequences. I am only mentioning the subject because there is now a ray of hope discernible for its correction.

In the last few years, we have witnessed an innovation in construction industry in the form of joint conferences and discussions between the various groups. At times we almost tire of the words "Cooperation" and "Conference," but these gatherings are gradually leading us toward a real understanding of construction and the means for its proper development. Practically every one of the conferences is developing information that has never been placed in written form and made available to those concerned. The members of these conferences are actually engaged in original study of construction economics.

Fortunately the thought is spreading through the industry that dishonest or incompetent concerns should not be allowed to disrupt or plunder public construction and corrective measures within the industry are taking form. A practical means of exercising intelligent selection of bidders and of knowing their qualifications has been devised by the Joint Conference on Standard Construction Practices. This Conference, composed of committees from nine national associations, has issued a standard form of questionnaire and financial statement for investigating the qualification of bidders. It has been officially approved by the American Association of State Highway Officials, and those who have developed the plan feel that its use will go far in elevating standards of performance within the industry. The application of these questionnaires and their results are being watched with interest by all who are concerned over the annual volume of defaulted contracts. They may not be as effective as we hope, but they will help greatly and above all they represent a concerted action on the part of all construction elements to exercise constructive cooperation.

The foregoing paper was read at the 1926 meeting of the American Road Builders' Association.

RECENT DEVELOPMENTS IN BITUMINOUS PAVING PRACTICE

By Harry M. Rex, Construction Engineer, North Carolina State Highway Commission, Raleigh, N. C.

While it is almost impossible to pronounce judgment with any degree of accuracy in considering the contemporary development of any field of endeavor, still it is possible to distinguish certain tendencies at least in the late developments in bituminous paving practice. Immense strides forward have been taken recently in all phases of this development which, for the purpose of discussion, may be aptly separated into two classifications, namely, improvements in asphaltic mixtures and construction methods, and second, the wider adaptation of bituminous construction to local materials and conditions.

Into the first category would fall, of course, the various bituminous binding

materials. Other than the extremely efficient standardization of production by the commercial manufacturers and the recent reduction of the too numerous grades of asphalt to a more practical few, no great change has occurred in the most of the asphaltic binders. This should not be construed as meaning that the present day specification standards should be passively accepted as representing the ultimate of perfection but merely that no eminent change in general asphalt requirements has come about in recent years.

This is not so, however, with the bituminous mixtures. From time to time various ideas have been advanced dealing principally with research into sand structures, and the introduction of admixtures. In the sense that thus far the worth of those mixtures generally termed standard remains unchallenged, no outstanding example of radically different asphaltic mixture has been advanced. Nevertheless, in this connection, there are two theories lately advanced and at present being investigated which are especially noteworthy.

The first deals with the proposition that higher percentages of added filler insure higher stability results and further that extreme fineness of this material is greatly to be desired. In addition the possible superiority of hydrated lime over the usual commercial limestone dust as a filler has also been indicated by laboratory tests.

The second theory is of peculiar significance to those districts where heretofore the fitting of local materials to meet gradation specifications has been acutely problematical. It maintains that much wider gradation limits on sands may be admissible than those which now prevail. For some years very interesting experiments dealing with sand structures have been conducted by a number of men actively engaged in highway research and a number of devices for measuring stability have been designed. Perhaps the latest of these is that of Mr. Prevost Hubbard, to whom credit is due for very valuable and interesting laboratory results in substantiation of this proposition.

At this time it is only possible to comment on the progress of these experiments as, I believe, no definite conclusions have been determined. However, examination of laboratory analysis of compacted bituminous samples lifted in North Carolina tend to bear out this second presumption. In other words there is no apparent correlation between excellence or inferiority of sand gradation and a high or low density (relative Solidity), all other influential factors being equal. It is a matter of fact that sands, in many respects far outside the bonds of what is commonly accepted as standard gradation, have sometimes been used in the construction of sand asphalt in North Carolina with gratifying results. The economic value of such widening of sand grading limits is readily apparent.

For the rest, as regards the asphaltic mixtures, it would be adequate merely to mention the growing tendency towards leaner mixtures to cope with modern traffic requirements. This applies not only to the finer graded surfacing mixtures but also to the large aggregate black bases, sheet asphalt binders and sand asphalt bases. In the latter mixtures the slight decrease in bitumen content, while sacrificing little of flexibility, appreciably increases stability.

The interest shown towards the constant improvement of asphaltic mixtures is equalled only by that directed to the betterment of construction methods. This is true from the viewpoint of not only the engineer but of the contractor as well. In general infinitely more care is being taken with the details of construction. Also it is being realized more than ever before that the riding quality and the durability of the wearing surface are dependent, either directly or indirectly, on every detail of the pavement structure from the subgrade on up to the wearing surface itself. Perhaps no better example of this can be taken than to observe the effect of the surface of a concrete base on a one-course bituminous wearing surface. If the base is rough and wavy these irregularities will show up in the surface of the top in the course of time regardless of how great pains are taken with the surface during construction of the wearing course itself. In this connection it is generally observed that while a truer surface may be obtained during construction in the case of fine aggregate mixtures laid in one course these mixtures are more sensitive to base irregularities than the mixtures in which the larger particles predominate.

Concrete base irregularities are commonly due to careless workmanship or to the lack of proper tools. The latter item is being better taken care of in North Carolina by the introduction of a transverse wood float used behind the usual tamping template and at the present time

experiments are also under way with the development of a longitudinal wood float for the use on concrete base. Two other details which have made for improvement in construction methods are the use of a straight edge on uncompacted hot-mixture materials and the decrease in depth of concrete header curb to insure the sealing of side joints. The exercise of great care in rolling the various mixtures is also becoming more universal.

Looking at progress in methods from the contractors' viewpoint the same advance in idea is seen. Strides have already been taken in breaking away from old, costly and inefficient methods which until a few days ago were handed down from year to year unquestioned. This has been accomplished by more progressive ideas along the lines of improved plant and equipment as well as more thorough organization knowledge. For example, in the year just past, two sand asphalt projects were awarded in North Carolina at the same letting. These projects were almost contiguous but were let to two different contractors at essentially the same unit bid price. One contractor, using a plant box of two thousand pounds, started his eight miles of work and finished 54 days after starting. The other contractor, using a thousand pound box, started his 10 miles the following day after the award and finished 126 days after starting. The former contractor had visions of improved construction methods and worked out their fruition; the latter merely did his work in the allotted number of working days. The advantages of progressive construction ideas —to the contractor in increased profits; to the engineer in better workmanship and lessened engineering cost—are obvious.

Thus we see important steps taken in the various improvements in mixtures and construction methods which can be paralleled in progress only by another phase of development. That is, the growing realization of the adaptability of asphaltic construction to local conditions and the utilization of known mixtures to the best advantage.

The sand asphalt pavement in North Carolina affords an ideal example of the use of local material to good advantage and also of the constant observation and improvement necessary to bring any given pavement up to as near perfection as possible. Although eminently successful generally field indications in some cases disclosed that which might develop into a structural defect. That is, a potential plane of cleavage was being created by the facts that the present pavement was being laid in two courses and that these courses were of very different mixtures. Although present specifications lower this plane of cleavage to a point having a reasonable factor of safety, experiments are now being carried on with the use of one course sand asphalt pavement laid to a compacted thickness of 3½, 4 and 4½ ins. Other experiments are being carried on with the use of a paint coat of hot asphaltic cement thinly and uniformly squeegeed on the sand asphalt base course prior to placing the wearing surface course. The success of this method has already been indicated. It has an advantage over the one-course sand asphalt in that it is perhaps possible to obtain a better surface with its use. Any of these solutions would completely eliminate the plane of cleavage of course.

Equally successful, not only in North Carolina, but in many other states, has been another type of unusual design. This, briefly, consists of a surfacing of an asphaltic hot mixture on either a new or old water bound macadam. The depth of stone in the macadam after compaction should be not less than 6 ins. If the reconditioning is to be done on all old macadam this will probably require scarifying the old stone and the addition of new stone to bring the total thickness to the proper depth. The stone is manipulated in the rolling, dusting and sprinkling as in the construction of ordinary water bound macadam. Just prior to laying the bituminous mixture the surface of the stone course is swept clean of dust to expose the top stones to a height of at least ¼ in.

Upon this base, to a compacted thickness of 2 ins., is then spread a modified Topeka mixture, closely resembling sheet asphalt in the gradation of the finer particles, and in the proportional relation of the bitumen content to the finer aggregate. It contains from 26 to 29 per cent of stone passing a ⅝-in. screen and retained on a 10-mesh sieve. To confine the mixture during compression, temporary wood headers are spiked to the desired width of surfacing. These are moved ahead as the work progresses and the edge of the asphalt surfacing is backfilled in the construction of shoulders.

One of the best examples of the facile nature of bituminous construction in making use of existing road structures is the reconstruction of old and worn-out penetration macadm roads. While condi-

itons in other localities may have required changes in detail the essential features of this type of reconstruction conform generally with the method in use at the present time in North Carolina. As these old roads, almost without exception, are much too narrow the first problem is one of widening. This may be accomplished with the use of either a Portland cement or bituminous black base with equal success. Due to grades which are extremely broken it is necessary to eliminate the worse irregularities in fitting the new grade line to the old. In doing this it is perhaps better to hold the new line slightly higher than the old as in filling in depressions between the new base side strips has proved more successful than trimming down places which are too high. These depressions in the old base are then filled with a rather open binder. It is important to emphasize the necessity for holding this binder course as lean and dry as is workably consistent. This binder course also ought not to exceed 4 ins. in compacted thickness.

After the inequalities in grade between the old base and the new base have been corrected so that the desired base cross-section has been accomplished a 2-in. wearing surface is superimposed thereon. This course may be of either a modified Topeka mixture or sheet asphalt.

This form of reconstruction is capable of transforming a superannuated road into a very serviceable road at a cost much less than that required for entirely new construction.

These three types—sand asphalt, salvaged water-bound macadam and widened and topped penetration macadam—illustrate adequately, I believe, the widening range of usefulness of bituminous construction in the semi-hard-surface field. In addition a new opportunity for development has sprung up in the need for what might be regarded as of the inferior classes of construction. This need dates from the institution of the Upham policy of progressive type construction and is in itself the acknowledgment of the lack of a suitable surfacing of a type higher than the topsoils and gravels, yet lower than the flexible types of hard surfaces. To meet this need several constructions have been experimented with, but to date only two of these have been developed to the point of moderate success.

Perhaps the most simple of these is the Upham type, and is accomplished by scarifying the existing sand clay or topsoil road to a 2 or 3-in. depth. Stone uniformly graded from 1 in. to 2½ ins. in size is then broadcast over the loose material in a uniform thin layer. Further manipulation by means of harrowing, puddling and machining thoroughly mixes the stone with the top layer of soil. When this operation is completed the stone course is thoroughly imbedded in the soil yet presents a uniform rough surface which will effectively anchor a hot mix surface to the topsoil roadway. Several surfacings have been used in these experiments. Although no extensive mileage has been constructed this idea is certainly worthy of intensive investigation.

A more elaborate and more expensive modification of this veneer idea is found in the shallow macadam surfacings to be seen to good advantage in Georgia. They differ from the Upham veneer in that no attempt is made to key the semi-flexible surface to the soil subgrade. The surface proper consists of 3 ins. of compacted penetration macadam constructed in the usual manner with the exception of the seal coat. After the intermediate size stone have been scattered over the penetrated large stone and thoroughly rolled a mixed seal coat conforming to sheet asphalt standards is placed thereon to the average thickness of 1 in. This mixture provides not only an effective sealing medium but also a very pleasing wearing course as well. Excellent drainage, is, of course, a prerequisite to the use of either of these veneer macadam types. In this connection it is of interest to note that Georgia has enjoyed considerable success with the use of an asphalt or relatively low penetration in not only the veneer macadam but also in the macadams of standard section.

An extensive and important investigation is also being carried on in the development of a surfacing which might be described as a medium between a veneer macadam and a surface treatment. While the true merit of these asphaltic oil roads has not as yet been positively determined the present indications signify an early success. It consists of a pliable extremely elastic mat built up by successive applications of asphaltic oil on a prepared soil road. Its three greatest advantages are the economy and ease of construction, its protection of the underlying soil road and its dust palliative properties. The present method of constructing this surfacing in North Carolina is as follows: Recognizing the fact that the finished surface will ride no smoother nor will it carry heavier

vehicles than the base, great care is taken in preparing the road for the treatment.

All weak places in the surfacing are repaired with good soil or gravel prior to treating after which the road is subjected to dragging, retaining a crown of from one-quarter to one-half inch per foot, until it is thoroughly compacted under traffic. Prior to applying the prime coat all loose material is removed from the road surface by means of machines and street brooms. A specially prepared tar is applied as a prime coat at the rate of three to four-tenths gallon to the yard and covered with from twelve to fifteen pounds of sand. This sand is uniformly distributed by dragging with sectional broom drags after about six hours. This coat is them allowed to set up under traffic for from five to ten days to allow volatile fractions to evaporate and to get the full colloidal effect of the tar.

All loose sand is then swept to the sides and a specially prepared asphalt is applied at the rate of from four to five-tenths of a gallon. About thirty pounds of sand per square yard is used as a blotter for the second coat which is broom-dragged as before.

The asphalt application is repeated from year to year building up a mat of from 2 to 3 ins. at the end of the sixth year. Patching and reconditioning are equally easy due to the gradual accumulation of this flexible mat which greatly distinguishes this form of construction from the ordinary oil-treated road—it has come to be generally known as the Bituminous Earth Road.

In conclusion this brief examination of the recent developments in the bituminous paving field has attempted to point out the following facts: First, there is revealed an increasing need for more thorough research into bituminous materials and mixtures, and for a closer co-operation between laboratory and field in the prosecution of such research; second, the engineering profession and the asphalt paving industry at large are challenged as never before to the improvement of construction methods with a view to economy; and third, the facile nature of asphaltic construction in road design as well as its ready adaptability in reconstruction work are every day attaining more universal recognition.

The foregoing paper by Mr. Rex was read at the 1926 meeting of the American Road Builders' Association.

RECOMMENDED PRACTICE FOR ARRANGEMENT OF BUILDING CODES

The Department of Commerce Building Code Committee has just completed, and the Department has published, a report on Recommended Practice for Arrangement of Building Codes. The committee was appointed by Secretary of Commerce Herbert Hoover early in 1921 to draw up more economical building regulations for use by states and cities, and the present report is the fifth of a series on building codes. The report presents a recommended outline for writing a building code, arranged by chapters, sections and subdivisions in the order in which reference is necessary to code provisions when a building is planned, designed and erected. Each chapter and section heading is followed by a brief explanation indicating the material which should be treated in a building code under the heading. It is expected that the outline not only will be useful in drafting building codes but that it will be very helpful to those designing buildings in the examination of unfamiliar codes to make sure no important requirements have been overlooked. A list of the chapter headings follows:

Chapter 1. Administration.
Chapter 2. Definitions.
Chapter 3. Classifications.
Chapter 4. General Building Restrictions.
Chapter 5. Zoning.
Chapter 6. Light and Ventilation.
Chapter 7. Means of Egress.
Chapter 8. Materials, Loads, Stresses.
Chapter 9. Construction.
Chapter 10. Precautions During Building Operations.
Chapter 11. Fire Protection.
Chapter 12. Chimneys and Heating Appliances.
Chapter 13. Special Occupancy Provisions.
Chapter 14. Elevators.
Chapter 15. Plumbing.
Chapter 16. Heating.
Chapter 17. Electrical.
Chapter 18. Signs and Billboards.
Chapter 19. Fire Extinguishing Equipment.

The report discusses briefly present diversity of building code arrangement and its influence on ease of administration and use. The need for greater uniformity

of arrangement is explained and the method advocated by the Committee is contrasted with others.

The Appendix deals with the relation of code requirements to the police power and gives much advice on the legal scope of code requirements. Some observations are presented on the value of a building code to a community. The report describes at length the customary methods of writing or revising codes and emphasizes the need of employing experienced consultants in such work. Directions are given for stating code requirements in a manner readily intelligible to the building public, and a strong plea is made for reduction in the number and variety of permits necessary for each building. A number of publications and information sources available to those writing or revising codes are listed in the Appendix and the best methods of printing code requirements are described.

The key-note of the report throughout is greater convenience for those planning and erecting buildings where this is consistent with the purposes of building regulation.

The report contains 30 pages and can be purchased from the Superintendent of Documents, Washington, D. C., for 10 cents.

ECONOMIC VALUE OF REINFORCEMENT IN CONCRETE ROADS

By C. A. Hogentogler, Highway Research Board, National Research Council, Washington, D. C.

(Editor's Note: Presented at Fifth Annual Meeting, Highway Research Board of the National Research Council at Washington, D. C., Dec. 3, and 4, 1925.)

Summary of Conclusions

1. The amount of cracking and subsequent disintegrating is a function of time; thus, the rate of cracking is a measure of the life of the pavement.

2. The data show that steel reinforcement reduced the rate of cracking and thus increased the life of the pavement. This applies both to concrete pavements and other pavements laid upon a concrete base.

3. Crack reduction is more economically accomplished by the use of steel reinforcement than by additional thickness of concrete.

4. A greater reduction was accorded by small steel members closely spaced than by larger members widely spaced.

5. Increased weight of mesh from 25 to 56 lbs. per 100 sq. ft. considerably reduced cracking.

6. Mesh reinforcement, 25 to 56 lbs. per 100 sq. ft., reduced cracks 35 to 70 per cent in pavements of like thickness.

7. Mesh reinforcement, 25 to 56 lbs. per 100 sq. ft. and bar mat reinforcement 64 lbs., per 100 sq. ft.—25 per cent longitudinal—reduced cracks more than one additional inch of concrete, but one additional inch of concrete reduced cracks more than bars (42 to 48 lbs. per 100 sq. ft.) placed transversely only.

8. With good crushed stone aggregate, 56 lbs. per 100 sq. ft. mesh reinforcement, or 170 lbs. per 100 sq .ft. bar reinforcement, 50 per cent each way, caused a reduction in combined transverse and longitudinal cracks equal to that indicated for 2 ins. additional center thickness.

9. Mesh reinforcement of 38 lbs. per 100 sq. ft. has been effective for a thin layer of concrete laid as resurfacing upon an old concrete road.

10. One additional inch of edge thickness reduced corner cracks more than mesh reinforcement 25 to 56 lbs. per 100 sq. ft., of ⅜ to ¾ in. bar reinforcement, but progressive destruction following the appearance of corner cracks was arrested by steel reinforcement.

11. All types of steel reinforcement across cracks tended to hold together fractured slabs.

12. Bar reinforcement across transverse joint, without proper provision for slippage and clearance, resulted in breakage and subsequent expensive repairs.

13. For long slabs, 75 to 100 ft. or over, edge bar reinforcement with continuous bond caused corner cracks if the area of steel exceeded ¼ sq. in.

14. A remarkable agreement was found to exist between results of observations on roads in service and results furnished by a wide range of experimental roads and laboratory tests.

WELDING ON BOILERS

By S. W. Miller, Past President of the American Welding Society, 30 E. 42d St., New York, N. Y.

In view of the ever-widening applications of fusion welding throughout industry and the probability that repairs to boilers made in this way will be pro-

posed from time to time, it is well that those responsible for the results should bear several points in mind. For simplicity, these are listed briefly below:—

1. Most boilers are insured.

2. Many boiler insurance policies are so worded that if repairs are made without the authority of the company carrying the insurance, the policy becomes void.

3. There are Federal, State and Municipal regulations governing this work, as well as those issued by the insurance companies.

4. Only competent welders, used to boiler work, should be allowed to do the welding.

Therefore, the following precautions should be observed by the owner or his representative:—

1. Examine the part of the boiler to be welded in company with the insurance company inspector, and get his approval before doing any welding.

2. Be present at the test after welding with the inspector.

3. If possible, get the inspector to sign a statement that thework has been properly done and that it has passed the test successfully.

4. If the boiler is not insured, and comes under Federal, State or Municipal supervision, carry out the above program in company with the proper authority.

If the boiler is neither insured nor under supervision of some constituted authority, ample precautions should be taken by the welder and the owner to protect themselves against possible future trouble. They should make a sketch of the location and size of the repair, with a clear statement of what was found wrong and how the repair was made. They should always make a hydrostatic hammer test of the finished job, using a pressure of 1-½ times the working boiler pressure, in the presence of witnesses, and get their signature to a statement of the facts. These papers should be carefully filed away. In such a case, no welding should be done which is not permitted by law or by good practice.

In case of marine work, the welder should pass the regular examination of the Federal Steamboat Inspection Service.

In all cases, the wolder should make friends of the insurance and other inspectors by refusing to do work unless authorized by them, by being conservative in what work he recommends, and by doing nothing except a first-class job.

WHAT'S THE MATTER WITH THE CONSTRUCTION INDUSTRY?

(From Southwest Builder and Contractor.)

"What's the matter with the construction industry?" That is a question raised by the conversation occasionally heard where several persons connected with the industry drift into a discussion of their business troubles. One remarks that the industry is drifting onto the rocks, another is certain it is headed for perdition, and still another declares that it has become so rotten he must get out of it at once.

Some years ago a now famous writer sprung suddenly into prominence by writing an editorial, "What's the matter with Kansas?" As a matter of fact there was nothing the matter with Kansas. It was merely a state of mind into which many people living in that commonwealth had allowed themselves to lapse by magnifying trivial things which annoyed them for one reason or another and the writer seized an opportune moment to make political capital out of the situation.

Perhaps the situation in the construction industry is analogous to that which existed in Kansas. Let those who are prone to be pessimistic about the industry take a survey of some other fields of business activity and make a candid and dispassionate comparison. We believe they will be enlightened and relieved of much fear and anxiety by so doing. There is no industry in which conditions are perfect, or even approximately perfect, although it may be one that has seemingly outdistanced all others in rate of progress.

As a matter of fact all industries have their troubles, some of which will abide with them always until the day of the millenium. Some industries may have been a little more successful than others in putting their troubles in the background and parading their optimism. But none of them have solved all their problems. Such a thing would be nothing short of a calamity for, having reached their goal, they would lose their urge and become stagnant; and stagnation begets retrogression.

We do not believe anyone connected with the construction industry today will have to look back very many years to convince himself that the industry has been getting better and is set firmly in the line of progress. A fair and calm judgment will compel the contractor to

admit that the standard of construction has been steadily raised, that the ethics of the business have been greatly improved and the character and ability of the men engaged in contracting is of a distinctly higher order. Likewise the material dealer must concede that despite his difficulties he is doing business under much more favorable conditions and that he is enjoying protection and advantages which not many years ago were only a faint hope. Nor can the architect or engineer disclaim any advancement in their professions. Their position in relation to all other elements of the construction industry and likewise the public is distinctly better, standards of both professions have been raised and they are reaping many benefits of mutual trust and co-operation.

Altogether the construction industry is going forward steadily and surely. It has not progressed as rapidly as some other industries because of lack of organization, but it is now beginning to gain some of the recognition to which its importance entitles it. It has many problems, some of which are vexing and irritating. They are being attacked, however, from many directions, and while complete solutions may not be reached in any particular case conditions will be continually and certainly improved.

We believe that every person connected with the construction industry may be proud of his affiliation. Undesirables creep in everywhere—in all lines of trade and manufacturing, in financial and commercial activities and all professions —and the construction industry is no exception. But the undesirables are becoming fewer and the capable and honest men predominate, so every man who would take pride in his vocation may hold his head high. There still remains, however, in the public mind, false impressions handed down from the days when the rough neck was conspicuous in the industry and perpetuated by careless speech among those connected with the industry, which must be dispelled. This will require time, but it will be hastened if those persons identified with the various branches of the industry are a little more thoughtful in what they say about each other and about their own business. If accusations must be made they should be specific. Don't smear them over the whole industry. Remember that where one man does not measure up to the standard there may be 99 others who do and they deserve consideration.

A WELL-LIGHTED RURAL HIGHWAY

The best lighted rural highway in the United States is claimed by Staten Island, N. Y., which nearly three years ago equipped the southern end of its fifteen mile Hylan Boulevard with lighting units and which has now continued the installation to include the remaining section of the highway.

The Staten Island highway is used extensively every night for taking produce and other farm products into New York City from New Jersey by automobile trucks. It is customary to ferry from Perth Amboy to Tottenville, proceed along the Hylan Boulevard across the island, and take the ferry from St. James to Brooklyn or New York, thereby eliminating the congested traffic along New Jersey and in the city.

The first lights were spaced 300 ft. apart on one side of the road. General Electric Novalux highway units, consisting of nested parabolic reflectors, were used. They are equipped with 250 candlepower, 6.6 ampere lamps, fed from 10 kw. RO transformers with automatic time control switches. The lights are mounted 32 ft., 6 in. above the road surface.

Hylan Boulevard is of concrete, 50 ft. wide, with space on each side for 10 ft. sidewalks so that when the road is finally completed it will be 70 ft. wide. The first installation included 119 units, and since that time 400 have been installed on boulevards of the island. The most recent installation of 225 units includes 187 for Hylan Boulevard and the others for Victory Boulevard.

The added units are spaced 300 ft. apart and opposite. In this case the concrete is 60 ft. wide, with an 8 ft. center parkway in which trees will be planted. Twenty foot sidewalks on either side are planned for a later date, making the highway 100 ft. wide.

The new installation gives Hylan Boulevard higher intensity of illumination than any other rural highway. There are 166 lumens per runing foot of road, compared with 83 lumens per running foot in the initial instalation, an increase of 100 per cent. The installation compares favorably with the Ideal Section of the Lincoln Highway where the same type of unit is installed on posts 35 ft. in the air and 250 ft. apart in staggered formation.

The Department of Water, Gas and Electricity, which has charge of street lighting in the Borough of Manhattan, is

rapidly replacing the standard bracket that employs a 20-in. flat reflector and 100 cadlepower lamp, it being claimed that one unit of 250 candlepower lights the road better and more efficiently than three of the former 100 candlepower units, with a corresponding lower annual charge

DRAWING ROOM PRACTICE TO BE STANDARDIZED

The American Engineering Standards Committee announces the launching of a comprehensive program of standardization of drafting room practice. This action follows the unanimous recommendations of a representative conference held in December, which was attended by 50 individuals, representing a total of 48 professional and trade associations, large engineering schools, and manufacturing concerns, particularly interested in drawings for shop and construction work.

Doing away with the diversity in drafting room practice and in the materials, equipment and tools used for making drawings, will result in a more ready understanding of drawings by anybody for whom they are intended, in great savings in the draftsman's time and efforts, and in a more efficient use of drafting materials and filing cabinets for the storage of completed drawings. One of the important items is, for example, the series of sizes for drawings. If these can be standardized, it will not only be possible to utilize drawing paper and tracing cloth as it comes in rolls or sheets, to the greatest advantage; but it will also be possible to supply the drafting department with sheets cut to size in advance, and on which the border line and the several spaces for title, the part list, etc., have been printed.

Besides the question of drawing sizes, the program adopted by the conference contains mainly the following items: classification of and corresponding nomenclature for drawing in accordance with their purpose; method of representation of the subject. as, for example, the arrangement of views and sections; indication of dimensions and tolerances; indication of surface or finish; symbols representing in a diagrammatical form certain elements of construction, as threaded parts, gears, etc.; the arrangement of drawings as to borderline, title, notes; indication of changes and revisions, method of folding, etc.; the kind and size of lettering, figures and symbols; scales of reduction or enlargement; sizes of filing cabinets; drafting equipment and tools (triangles, scales, etc.); specifications for materials to be used for drawings (paper, tracing cloth, inks, pencils, etc.).

The work will be carried out by a large sectional committee on which all interested groups will be represented, under the sponsorship of the American Society of Mechanical Engineers and the Society for the Promotion of Engineering Education.

SHORTENING CREDIT ON CONSTRUCTION EQUIPMENT

One of the principal factors in influencing the destructive competition prevailing in highway work has been the attitude of certain distributors of contracting equipment who have been willing to sell equipment by taking a small down payment and giving extremely long terms for the payment of the balance. This policy has encouraged contractors with little capital to become engaged in paving work as well as assisting others of limited resources to expand beyond the bounds prescribed by sound business principles.

The Associated Equipment Distributors have recognized this factor as well as the danger of their own industry and by resolution of their Executive Committee have condemned the practice of extending long terms for the payment of construction equipment.

The resolution reads as follows:

"Whereas, Long time financing of construction equipment in our belief aids in establishing in the construction field irresponsible people or firms during a period of increased construction to the detriment of established reliable and experienced persons or firms who are devoting their life to the construction field;

"Be it Resolved, That the Associated Equipment Distributors and its members hereby go on record as being opposed to attempts now being made by finance corporations to establish in the construction equipment field the method of purchasing machinery on small down payments and notes over a long period of time.

"Be it Further Resolved, That in the belief of the Associated Equipment Distributors the longest time payment that should be accepted on all but the heaviest machinery should be part cash and notes not to exceed 120 days."

SUPREME COURT DECLARES TEXAS ROAD DISTRICT LAW INVALID.

(Editor's Note: The following is from "The Bond Buyer" for Jan. 16, 1926.)

A decision of the United States Suremp Court of the utmost importance to municipal bond dealers and investors was handed down on Monday, Jan. 4, 1926.

Careful consideration of the opinion, full text of which appears below, has led investment dealers and bond attorneys to conclude that it casts doubt upon the validity of a great mass of district obligations originating in many States. That the situation brought about by this remarkable ruling of the highest court in the land is one of utmost seriousness is made clear by the following telegram received by "The Bond Buyer" under date of Jan. 8:

St. Louis, Mo.,
Jan. 8, 1926.

The opinion speaks for itself. We hope that there will be a rehearing and a modification of the opinion because if the court adheres to this decision the damage will be countrywide. Similar districts have been created in many other States and such districts have issued bonds ,the validity of which is imperilled by this decision. The damage in and to the State of Texas alone is enormous. The opinion is contrary to some principles which all Americans have thought well fixed.

(Signed) ALDEN H. LITTLE,
Chairman, Municipal Securities Committee, Investment Bankers Association of America.

Bankers, bond dealers and public officials in Texas appear to be greatly alarmed over this adverse Supreme Court ruling and the possibility of widespread publicity in northern investment centers. The Republic Trust and Savings Bank of Dallas, on Jan. 7th, sent the following telegram to certain banks and news agencies in New York urging that it be given the widest publicity:

With reference to the opinion of the Supreme Court of the United States on the vailidity of certain unsold Special Road District bonds of Archer County, Texas, this bank wishes to endorse most cordially the sentiment of Mr. Dan Moody, Attorney General of Texas, who in today's press says:

"Certainly no one believes that there will be any repudiation of any public debt in Texas. The good name of the State and the quality of her citizenry are ample guarantees that whatever is necessary will be done in order to make sure that people who have bought Texas bonds will be paid their money."

We believe with the Attorney General that the proper authorities will take every necessary action to preserve the credit and good name of Texas in the business world and that the bonds of the road districts involved by implication or otherwise in the Supreme Court's opinion will be promptly met principal and interest. In expressing this opinion, we wish to assure the bankers and the investing public of this country that this bank pledges itself to use every proper effort to the end that the rights of holders of Texas Road District bonds be protected.

Application for Rehearing Will Be Made

The Attorney General of Texas, with whom Thomson, Wood & Hoffman, counsel for the Investment Bankers Association, and other eminent attorneys will join, will seek a rehearing of the case and there can be no doubt that opportunity will be had to reargue the matter from the standpoint of its far-reaching effect upon improvement districts of all sorts which have been created in many States.

It has been estimated that in Texas alone road district bonds are outstanding in the amount of $75,000,000. In numerous other States, the road district has similarly been the agency used in developing extensive systems of modern highways and the total amount of bonds issued by such districts throughout the country is undoubtedly very great. Satisfactory statistics on this class of securities are not available. "The Bond Buyer's" record of municipal financing in 1924 and 1925 do show, however, that in 18 States road district bond issues were floated, the State totals for this class of borrowing in the year 1925 ranging from a few thousand dollars up to no less than $15,000,000. It does not follow that bonds, simply because they are obligations of a road district, are in any manner affected by the Supreme Court's ruling. In fact, in many instances this

is quite clear, even to a layman. On the other hand, attorneys who are giving the opinion their most profound consideration point out that it may apply to districts created for purposes other than roads.

The issues of Texas road district bonds in 1925, as reported by "The Bond Buyer," aggregate $2,522,500. In 1924 the total was $5,923,500.

The opinion, in full, follows:

SUPREME COURT OF THE UNITED STATES

No. 256.—October Term, 1925.

Perry Browning et al., Appellants, vs. E. M. Hooper et al.

Appeal from the United States District Court for the Northern District of Texas.

(January 4, 1926.)

Mr. Justice Butler delivered the opinion of the Court.

Appellants own taxable real and personal property in that part of Archer County, Texas, defined as Road District No. 2. The appellees are the county judge and four commissioners, (constituting the county commissioners' court), the tax assessor and the sheriff of the county, who is the tax collecter. Appellants brought this suit to restrain the issue or sale of bonds of the road district in the amount of $300,000 proposed to be sold to obtain money for the construction, operation and maintenance of roads in that district, and to restrain the levy or collection of any tax upon their property to pay any part of the interest or principal of the bonds. They seek relief on the ground that the creation of the road district and the enforcement of the proposed tax, will deprive them of their property without due process of law in violation of the Fourteenth Amendment. The District Court dismissed the complaint. 3 F. (2d) 160. The case is here on direct appeal. § 238, Judicial Code.

The Texas statutes (Vernon's Complete Texas Statutes, 1920) provide: "Any county . . . or any political subdivision or defined district now or hereafter to be described and defined, of a county," is authorized to issue bonds, not to exceed one-fourth of the assessed valuation of real property in the district, for the construction of macadamized, graveled or paved roads and turnpikes, and to levy and collect taxes to pay them. Art. 627. Upon the petition of 50 resident property tax paying voters of any defined district of any county, it is the duty of the commissioners 'court to order an election in the district as described in the petition to determine whether its bonds shall be issued for such road purposes, and whether a tax shall be levied upon the property of the district for their payment. Art. 628. If two-thirds of the votes cast are in favor of the proposition, the commissioners' court is required to issue and sell the bonds. Art. 631. But before they are put on the market, the court is required to levey a tax sufficient to pay the debt as it matures. The assessments are to be made on the same valuation, and they become liens and may be enforced in the same manner as State and county taxes. Arts. 634, 2827, 2836. For the purpose of the act, any district accepting its provisions by such vote is thereby created a body corporate which may sue and be sued. Art. 637.

Archer County is about 30 miles square, and has a population of between 5,000 and 6,000. The principal place is Archer City, the county seat, located about five miles south and three miles east of the center of the county. Road District No. 2 embraces approximately the northerly half of the county, including a part of Archer City. The Ozark Trail is a Federal aided State highway, and about 20 miles of it extends diagonally across the northwesterly part. Dundee is located on it about two miles from the west line of the county. There is a highway extending from that place to Diversion Dam about six miles northwest. About 18 miles of the Southwest Trail lies between Archer City and a point on the north line of the county about six miles from its northeast corner. There is another highway extending from a point on the Southwest Trail about two miles south of the county line to Holliday on the Ozark Trail about six miles west. These roads are within the road district, and the bonds issued are to raise money to improve them.

January 17, 1924, there was presented to the commissioners' court a petition signed by 74 persons. It prayed an election to determine whether bonds of the territory, therein described by metes and bounds, and to be designated as "Road District No. 2 of Archer County, Texas," should be issued for road purposes in the amount of $300,000; and whether a tax should be levied upon the property there-

in to pay the bonds. The commissioners' court by order established the district within the metes and bounds and for the purposes set forth in the petition, and declared it to be a body corporate. On the same day the court fixed the time and place for an election. Its result was 303 votes for and 102 against the bond issue. Thereupon the court ordered the bonds to be issued, and levied the taxes. Before the election was called, the court determined that the proceeds of the bonds, if voted, or so much as might be necessary, should be expended for the roads above described.

The appellants' lands—24,900 acres in all—are in the northeasterly part of the county. All but one of the petitioners are residents of the part of Archer City that is within the road district. Archer City, Dundee and Holliday, furnished 252 votes for the bond issue,—more than twice the number cast against it. Nearly all the votes cast in the northeasterly part of the county were negative. The taxable property in the district is assessed at $5,683,359, of which $257,080 belongs to appellants, and $11,388 to petitioners; and $60,500 of that amount belongs to one signer, leaving only $50,888 to the other 73. The part of the district in which appellants' lands are situated is tributary to Wichita Falls, which is outside Archer County, but near its northeast corner. The evidence presuasively supports appellants' contention that the improvements of the roads designated will not benefit their property. Moreover, the inclusion of their lands in that road district makes it impossible until the last bonds mature 30 years hence, to create another road district to raise money for the improvement of roads needed to serve the territory in which their lands are situated. Art. 637d.

Resort may be had to general taxes and to special assessments to raise funds for the construction or improvement of roads. Missouri Pacific Railroad v. Road District, 266 U. S. 187, 190. The proceedings in this case cannot be sustained as the levy of a general tax. The commissioners' court is authorized to levy general taxes for road purposes up to a stated maximum on each $100 valuation. Art. 2242; Constitution Art. VIII, § 9. The expenditure of the moneys so raised is not limited to any specified roads. And it is significant that, in the case of a road district, the court's duties in respect of the amount to be raised and the lands to be subjected to the charge are purely ministerial, and confined solely to carrying out the will of the petitioners when approved at the election. Here, at the initiation of individuals signing the petition, a special district was carved out to furnish credit and to pay for specified improvements on designated roads wholly within the territory selected. The purpose was special, and the district will cease to exist as a body corporate upon the payment of the bond debt. It is clear that the burdens here sought to be imposed on appellants' lands are special assessments for local improvements. Embree v. Kansas City Road District, 240 U. S. 242, 247; Illinois Central Railroad v. Decatur, 147 U. S. 190, 197, 209.

The legislature did not create the road district, levy the tax or fix the amount to be raised. Under the act, road districts are not required to correspond with or to include any political subdivision. Moore v. Commissioners' Court, (Tex. Civ. App.) 175 S. W. 849; Bell County v. Hines, (Tex. Civ. App.) 219 S. W. 556. There is nothing in the law to guide or to limit the action of the signers of the petition in selecting property to be assessed. Subject to the vote of a district of their own choice, the petitioners' designation is absolute. The commissioners' court has no power to modify or deny; it is bound to grant the petition. Huggins v. Vaden, (Tex. Civ. App.) 253 S. W. 877, 878; 259 S. W. 204, 206; Meurer v. Hooper, (Tex. Civ. App.) 271 S. W. 172, 176. And when the required vote is given, the court once for all, must make a levy on the taxable property of the district sufficient to pay the entire debt as it matures. The opinion of the District Court states that the road district "was composed of two of the precincts of Archer County—'political subdivisions' of the county well recognized and ascertained long before the controversy." We find nothing in the record to support the statement. But, if true, it does not tend to show that the legislature created the road district. A political subdivision is not a "defined district" within the meaning of the Texas Constitution (Art. III, § 52) or of the act. It has been held by the Texas Court of Civil Appeals that a"defined district" means a defined area in a county, and less than a county, other than a politiacl subdivision of a county. Bell County v. Hines, supra, 557. The fact that the metes and bounds describing the road district hap-

pened to coincide with the external boundaries of two adjoining commissioners' precincts does not support the contention that the road district was created by the legislature. For the election of commissioners, each county is divided into four precincts, from each of which a commissioner is elected. These precincts are not defined by the legislature, but by the commissioners' courts. Art. 1356; Constitution, Art. V, § 18. They are political subdivisions, but, unlike road districts, they are not bodies corporate. See Ex parte Haney, 51 Tex. Cr. Rep. 634; Cofield v. Britton, (Tex. Civ. App.) 109 S. W. 493, 496. They are not taxing or assessment districts; their powers and functions are wholly different from those of a road district. And plainly, the authority granted (Art. 627) to issue road bonds up to one-fourth the assessed valuation and to levy taxes ratably to pay them is not a legislative determination of the rate or amount of the tax imposed on appellants' property. The amount of the bonds to be issued and the property to be taxed are the elements which determine the burden. These were fixed by the petition and election. The legislature may make assessments for local improvements ratably on the basis of the property valuation (Valley Farms Co. v. Westchester, 261 U. S. 155); but, where the amount to be raised is determined and the property to be assessed is selected as in this case, the requirement that the burden shall be so spread is not a legislative assessment.

Where a local improvement territory is selected, and the burden is spread by the legislature or by a municipality to which the State has granted full legislative powers over the subject, the owners of property in the district have no constitutional right to be heard on the question of benefits. Valley Farms Co. v. Westchester, supra; Hancock v. Muskogee, 250 U. S. 454, 459; Withnell v. Construction Co., 249 U. S. 63, 69; Wight v. Police Jury, 264 Fed. 705. But it is essential to due process of law that such owners be given notice and opportunity to be heard on that question where, as here, the district was not created by the legislature, and there has been no legislative determination that their property will be benefited by the local improvement. Appellants were denied all opportunity to be heard. No officer or tribunal is empowered by the law of the State to hear them, or to consider and determine whether the road improvements in question would benefit their lands. The act is repugnant to the due process clause of the Fourteenth Amendment. Embree v. Kansas City Road District, supra, 251.

Decree reversed.

OFFICERS OF AMERICAN ROAD BUILDERS ASSOCIATION

At a meeting of the nominating committee held in New York City, Henry G. Shirley, chairman of the Virginia State Highway Commission was unanimously chosen as president for 1926-1927 of the American Road Builders' Association, the oldest and foremost organization identified with the good roads program in this country and the sponsor of the great good roads convention and exposition to be held in Chicago, January 11-15, 1926.

James H. MacDonald, former state highway commissioner of Connecticut and a road expert residing at New Haven, will continue as treasurer. Charles M. Upham, state highway engineer, Raleigh, N. C., is business director and convention manager of the association and Miss Ethel A. Birchland of New York City is secretary.

The following men have been nominated for the seven directorships to be filled at the Chicago meeting: F. A. Reimer, consulting highway engineer, East Orange, N. J.; W. H. Kershaw, The Texas Company, New York City; C. M. Pinckney, chief engineer, Bureau of Highways, Manhattan Borough, New York City; Col. R. Keith Compton, director of public works, Richmond, Va.; C. M. Upham, state highway engineer, Raleigh, N. C.; William Ogden, Lakewood Engineering Co., Cleveland, O., and Frank Terrace, president, Washington Good Roads Association, Orillia, Wash.

Mr. Shirley, who will become president, has long been identified with America's highway program and is widely known for his achievements in the construction field. After graduating in engineering at the Virginia Military Institute he became roads engineer for Baltimore County, Md., and then highway commissioner of that state. At one time he was secretary of the American Highway Industries Association and president of the American Association of State Highway Officials. During the World War he was a member of one of the committees assisting the government with wartime highway matters.

RESUME OF ANNUAL MEETING OF HIGHWAY RESEARCH BOARD

The fifth annual meeting of the Highway Research Board was held at the National Academy of Sciences and the National Research Council at Washington, D. C., on Deecmber 3 and 4, 1925. The Registration totaled 300, representing 28 states, 25 universities and 2 foreign countries. The sessions were presided over by Dean A. N. Johnson, University of Maryland; A. J. Brosseau, Mack Trucks, Inc.; E. J. Mehren, Engineering News-Record, and Dr. W. K. Hatt, Purdue University.

A brief resume of the proceedings follows:

Dr. Vernon Kellogg, permanent secretary of the National Research Council, welcomed those in attendance in a short address, in which he pointed out the great value of scientific research and its importance in road building. Thomas H. MacDonald, chief, U. S. Bureau of Public Roads, in a brief address called attention to the international aspects of highway research and gave some of his observations in connection with his recent tour through South America.

Charles M. Upham, director, Highway Research Board, called attention in his report to the growth of this organization, which now has active contact men in 44 state highway departments and 121 universities, as well as contacts with Latin American countries. He pointed out that in addition to its research committees, the board now has under way four special investigations financed by industrial concerns, and headed by paid chairmen, who, in most cases, gave their entire time to the work. These investigations are: A study of the economic value of reinforcement in concrete roads; an earth road investigation; a culvert investigation, and an urban highway finance investigation. Mr. Upham called attention to the importance of each of these studies and the great fund of valuable inormation that is being secured on each through the splendid cooperation of the state highway departments and other research agencies. Mr. Upham concluded by stating that the Highway Research Board offers a logical meeting ground for representatives of industry, engineers and research workers engaged in the highway field to get together to discuss their common problems which can be solved by scientific research.

Report of Committee on Economic Theory of Highway Improvement, Chairman, T. R. Agg, Iowa State College

Relation of tire tread wear to type and condition of road surface. The investigations on this subject show the following preliminary results:

Tire wear indices for various road surfaces—

Roard Surface.	Index Number
P. C. Concrete	1.00
Monolithic brick	1.01
Bituminous filled brick	1.00
Iowa gravel	2.20
Chert gravel	7.30
Bituminous macadam without seal coat	10.60

Other investigations show that the rate of tire wear on macadam is 17 times as great as on concrete, and may be 56 times as great on poor macadam.

Intensity of downward kick of rear wheels of vehicles starting from rest.—Theoretical analysis and experiments with twelve vehicles tend to show that the intensity of the downward kick ranges from 100 lbs. to as much as 1,000 lbs.

Relative wear and tear upon highways produced by light and heavy trucks.—The complete report presents data covering a wide variety of vehicles operated under diverse conditions.

Riding qualities of road surfaces, rolling resistance and gasoline consumption on typical highways are being studied, but these projects are not in the stage where results are available.

Report of Committee on Structural Design of Roads, Chairman, A. T. Goldbeck, Formerly with U. S. Bureau of Public Roads

Subgrade investigations. The most unfavorable subgrade conditions are due to excess moisture in soils that are affected thereby. Such excess moisture results from (a) poor surface drainage, and (b) poor internal drainage.

Under the most favorable climatic conditions few failures are due to the subgrade. Favorable climates involve moderate temperatures with comparatively low precipitation, and particularly low precipitation during the winter months. Unfavorable climates have long continued periods of cold weather; high precipitation during freezing weather; or frequent alternations of freezing and thawing combined with deep freezing.

Additional information on admixtures for subgrades is included in the report.

Tests indicate that concrete, when reinforced with small amounts of steel, may be extended more without visible cracking than when unreinforced.

The extensibility of dry concrete beams was found to be less than that of wet specimens.

Deformation measurements in existing concrete roads furnish an excellent index of the load-carrying ability of the slab. The recent measurements corroborate the thickened edge design. Tests in Cook County, Illinois, indicate that a 9-7-9 section is suitable for an 8,750-lb. maximum wheel load.

It is indicated that, for all practical purposes, the stress produced in concrete pavements is directly proportional to the wheel load.

Within practical minimum limits of axle spacing, the individual axle loads of a six-wheel truck may be as heavy as in the case of a four-wheel truck.

Theoretical stress analysis.—Stresses in concrete pavements have been determined by the mathematical theory of elasticity closely approximating those determined by test measurement. Table of stresses have been prepared from which it is possible to proportion the slab under given conditions.

The analysis shows that the "stiffness factor" of the subgrade does not greatly affect the pavement stresses.

Planes of weakness introduced in concrete roads—Attention is called to a promising experiment in which an attempt is made to control the transverse cracking in concrete pavements. This is done by creating transverse planes of weakness in the pavement during construction.

Report of Committee on Character and Use of Road Materials, Chairman, H. S. Mattimore, Pennsylvania State Highway Department

High alumina cement.—High alumina cements are reported to be resistant to acid and alkali waters. The strength of this class of cement at 24 hours is equivalent to that of Portland cement at 28 days, but its behavior in long-time tests is not definitely known.

While the cost of high alumina is from two to three times that of Portland cement, it has been successfully used on special construction.

Zone paints.—The conditions under which zone paints for highways are used, suggest that the following are the most important factors involved, and are the ones for which various laboratory tests are essential in selecting paint for such service:

1. Consistency (i.e., freedom from clogging tendencies when applied by the prevailing methods).
2. Spreading rate.
3. Hiding power (capacity).
4. Drying time.
5. Light resistance.
6. Visibility (both day and night).
7. Durability (resistance to weather and abrasion).

The complete report contains suggested types of apparatus for the above tests.

Accelerators in Portland cement concrete.—The various investigations reviewed in this report indicate that calcium chloride and compounds with a calcium chloride base may perform the useful function of accelerating the hardening of concrete. The rate of acceleration for the compounds commonly used is in a direct relation to the calcium chloride content.

The principal advantage of these accelerators is the securing of early high strength. This results in the earlier possible use of the structure and in protection against adverse curing conditions.

Report of Committee on Highway Traffic Analysis, Chairman, G. E. Hamlin, Connecticut State Highway Commission

The three-lane two-way roadway.—A three-lane two-way roadway is one upon which the traffic movements are in both directions, and which is only wide enough for three moving vehicles to be abreast.

The actual traffic capacity of a two-lane roadway varies within wide limits. It is evident that a three-lane roadway will permit vehicles to pass each other with a greater frequency than on a two-lane road. The three-lane roadway, however, provides conditions under which accidents may frequently occur. The committee recommends the use of a four-lane roadway when the capacity of the two-lane two-way roadway is exceeded.

Highway traffic.—Transportation surveys indicate a close relationship between population per square mile, the trend of population, growth and industrial development, and the amount of traffic using the highways.

The prediction of expected future traffic based on the projection of the trend of motor vehicle registration is a reasonably accurate measure of future highway traffic.

Elimination of obstacles impeding the free flow of traffic.—The movement of

traffic over any route depends upon its ability to move freely at all points.

The committee believes that the elimination of obstacles to traffic on many highway routes will be justified by the increase in the safe movement of traffic; and in some cases, the program of widening can be economically deferred by this method.

The committee recommends, in the construction program for highway improvement, that there shall be seriously considered the planning for arterial highways outside the congested areas.

The committee is of the opinion that, in many cases, the installation of a fixed signal supported by a pedestal at the intersection of highways is not justified.

Adequate rights-of-way.—The committee recommends the following.

1. Determination of present right-of-way.
2. A highway transport survey to determine necessary required widths.
3. Acquisition of additional necessary width.
4. Simplification of method of acquisition to permit immediate occupancy.

Report of Committee on Maintenance of Roads, Chairman, W. H. Root, Iowa State Highway Commission

Dust prevention and surface treatment of gravel and macadam roads.—Light asphaltic oils are used to a limited extent and are effective for six weeks to one season. Two or three applications of calcium chloride are effective for one season, and a cumulative effect is noted after two or three years of treatment. Bituminous mats are maintained on gravel by using both hot and cold applications. Two treatments in three years or three treatments in four years are necessary.

Crack fillers for concrete pavements.—Lack of uniformity of specifications of various states is shown. The standard penetration of asphalts ranges from 35 to 250. Patented crack fillers have, in general, proved unsatisfactory.

Snow removal.—A complete report for the winter of 1924-25 shows that 48,000 miles of road were included in the snow removal program of 35 states. Nine states include their entire road system in the snow removal program. The cost of snow removal is greatly diminished by proper attention to drift prevention. Four requirements of organization are: (1) an efficient organization, (2) a definite program, (3) suitable and ready equipment, and (4) a plan of action that will start with the storm and continue until the roads are open.

Guide, caution and danger signs.—Uniform signs and a comprehensive nation-wide number system have been adopted by the National Committee on Signs, and are rapidly being put into effect by various states.

Standardized maintenance accounting.—Progress is shown in the use of standardized methods of accounting. Of 20 states reporting, eight are now using the American Association standard recommendations, three a modification of this system, three favor it but are not using it, and six report individual systems.

Relation between age of pavement and annual maintenance costs.—Pavement age has a definite effect on maintenance costs. Maintenance records since 1888 on asphalt pavements at Columbus, Ohio, show repair costs to increase somewhat uniformly with the age of pavements. At the critical period, the tenth or thirteenth year, there is a marked increase in maintenance cost, reaching a maximum average of 1 percent per square yard.

The report also discusses coverings of disintegrated concrete roads, and the methods and effects of bituminous treatments of earth, sand-clay and top-soil roads.

Progress Report of Culvert Investigation, R. W. Crum, Iowa State Highway Commission

This investigation was undertaken by the Highway Research Board at the request of various interested parties, who felt that extensive investigations of existing small drainage structures throughout the country would be of great value in establishing principles of design and construction for such structures. It is well known that there is a very great diversity of opinion and practice in this field of work. It was expected that the first duty of this committee would be to endeavor to outline acceptable methods of procedure for the making of such investigations so that the data secured by the various agencies in their own localities would be of comparable value and lead to sound conclusions. It was further hoped that this committee would later have an opportunity to study the mass of data thus collected. No doubt in order to establish the basic facts upon which the economic value of the different types and classes of small drainage structures depends, for varying local conditions, the correlation of the data from many thousand examinations will be required.

For the purpose of clarifying the objectives of this investigation, a conference was held on Nov. 5, 1925, which was attended, on invitation, by representatives of the material interests involved and by several engineers particularly qualified to give helpful counsel.

It was agreed at this meeting that this investigation is "for the purpose of conducting a fact finding survey of small drainage structures to determine *methods* of arriving at the economic values of various types of such structures in highway construction."

Stated in another way, the ultimate objective of this investigation is to provide the engineer with the basic principles by which he may decide upon the economic structure to use under a given set of conditions.

The committee recognized as its first duty the development of procedure for the examination of these structures in the field and the recording of the data thus secured. We are pleased to report satisfactory progress toward this objective. A sufficient amount of field work has been done, to afford a basis for tentative recommendations as to such procedure. We will discuss certain aspects of the matter of a scheme for classification and rating of the individual structures. The time has been too short to permit of the careful consideration that this important feature merits and we will therefore have to postpone the recommendation of a scheme of classification until further study clarifies our opinions.

In our field work we have visited 14 states and have examined 516 culverts. Details noted were recorded during the course of each of these examinations. Considerable general information was also obtained from casual observations of a number of installations for which no history of past life was available. Conferences and interviews with highway officials and highway engineers were of great assistance in the identification and classification of local conditions. The more important impressions gained during this survey of the existing field conditions and of the services rendered by small drainage structures were as follows:

1. That the combined effects of local conditions are relatively few for each type of installation.
2. That a particular type of failure is common for a given type of installation.
3. That the usual range in height of fill for highway culverts is from 1 to 5 ft. over top of culvert.
4. That sufficient attention has not been given to the design of culverts, heretofore.

HIGHWAY SIGN PAINTS TESTED IN WISCONSIN

By G. F. Daggett, Materials Engineer, Wisconsin Highway Commission, Madison, Wis.

(From the December, 1925, issue of "Badger Highways," published by the Wisconsin Highway Commission.)

The Wisconsin Highway Commission is charged with the marking and signing of 10,000 miles of state trunk highways, and in addition to this, the counties are required to mark and sign 10,000 miles of county trunk highways. This work involves the preparation and painting of a large number of signs of all classes, and the use of several hundred gallons of black paints and white paints during the course of a year.

From time to time questions were being asked of the Wisconsin Highway Commission Materials Laboratory regarding the suitability of various paints for highway marking signs and road fences. The nature of the questions involved points upon which paint experts are in more or less disagreement. Furthermore, such points could not be cleared by reference to available literature covering tests made by various technical societies.

After consulting with Dr. F. L. Browne, the paint technologist of the United States Forest Products Laboratory, in Madison, it was decided to proceed with a service test of white and black paints offered in the open market as being suitable for use in painting marking signs and guard rail fences. Samples of such paints were obtained through the courtesy of dealers and manufacturers supplying consumers in the state.

Before planning the test, a copy of a circular letter was sent to each division office, requesting information and comments on the procedure followed in applying paint to road signs. The test was planned and carried out after careful consideration of the seven letters which were received in answer to the circular.

In order that this experiment might be carried on by a person thoroughly acquainted with paints, a master painter was engaged to work under our general supervision in the mixing of the samples.

Each sample of white paint as received was divided into three portions. By adding known amounts of linseed oil and tur-

pentine, each portion was thinned out and made suitable for application as first, second, or third coat. Black paints were prepared for application in one coat. White paints were applied in three coats to a series of yellow pine panels; black paints were applied in one coat to a series of cedar panels. The amount of paint applied to each panel was carefully weighed in order to determine the spreading power of each paint. After the white paints were dry, ten days being allowed for the drying of each coat, the panels were lettered and numbered, a different kind of black paint being used for each panel. Ten more days were allowed for the complete drying of the paint, and then the panels, about five hundred of them, were mounted during the first week in October, 1925, on a test fence erected for the purpose. It is located close to a gravel road near the village of Pheasant Branch, on Lake Mendota, in Dane County.

The behavior of each paint will be observed and failure will be noted by means of field tests and careful inspections made at regular intervals of time, extending probably over a period of two years.

The engineers of the commission will be kept advised of results as they appear from time to time. It is rather interesting to note that one sample of black paint has already failed.

This work is under the direct supervision of Mr. Jose Zapata, one of the testing engineers of the Highway Commission.

PROCEDURE IN HANDLING FEDERAL AID PROJECTS

By Frank Cnare, Plan Engineer, Wisconsin Highway Commission, Madison, Wis.

(The following article is from a reecnt issue of "Badger Highways.")

The Bureau of Public Roads has adopted certain rules and regulations which must be followed when Federal plans are submitted by the various highway commissions. Up to the present time plans for about 420 projects have been submitted by the Wisconsin Highway Commission to the District office of the Bureau, and although, in some instances, the rules covering their preparation have not been strictly followed, the Federal District office has always been ready to help the Highway Commission in its troubles when certain special conditions have made it difficult to follow the rgeulations laid down.

In order to obtain a comprehensive knowledge of the highway which it is planned to improve, the Bureau of Public Roads requires that certain information be submitted before it will enter into an agreement with the state to pay Federal Aid in road construction. This information is contained in the form of a project statement, plans, and an agreement estimate. After it has signed these papers the Bureau will enter into a project agreement, or contract to pay Federal aid. The important points to each of these papers will now be taken up and discussed in detail.

Project Statement and Sketch

The information contained in the project statement is general in character. Under the latest regulations the project statement is a general description of the route between two cities, the junctions of Federal highways, or between any other points which are natural points of separation. The route is intended to cover the work of not more than ten individual jobs which are to be lettered from A to J, inclusive, and of which any number may be constructed in any one year. The gross length of a project is the total length between such termini or points, less the lengths of any Federal projects which have already been constructed. The net length is the gross length less the distances within the construction limits of cities.

When a project statement is submitted it is necessary to specify and define a certain section (as "Section A") as being a candidate for construction, but the limits of such section may be changed and the Federal government does not insist that the section so described be built at once. The government purposes to cover the entire Federal system with project statements, and, through inspections made by Federal representatives, to obtain a comprehensive knowledge of the condition of the Federal Aid roads, which information should soon be available in the official records of the bureau.

Any one section of a project, such as "Section A," must not cover both a primary and a secondary Federal highway. If such construction overlapping two classes of Federal highways is contemplated, the project must be divided into sections, each section covering only one class of highway. A rough estimate of "Section A," or whichever section is in question, and also of the entire project,

is given in the statement, together with the source of state funds, funds provided for maintenance, or the legal authorization for such provision, the cities of 2,500 population and over located on the section, the names of the engineers making the estimate and inspection, and any other information which may be necessary.

The project sketch, usually drawn to a scale of one-half inch to the mile, must accompany the statement. The termini of the project, the limits of the section, the connections and numbers of other Federal highways, the location, sizes, and condition of bridges, the location and class of all railway crossings, the location of Federal projects previously built, and the present types of surfacings are a part of the information shown on the sketch.

The project statement and sketch must be approved and signed by the State Highway Engineer for the Highway Commission. Three copies of the statement and four copies of the sketch are then sent to the Federal District office, and forwarded to the bureau for its approval. The project statement and sketch must be approved by the Bureau of Public Roads before a contract can be awarded for any work.

Plans

Surveys and plans may or may not be in process of preparation, but no plans are approved by the bureau prior to the date of approval of the project statement. Plans are drawn in the Highway Commission's Division offices and are sent to Madison in pencil for tentative approval of grades and alignment. They are then returned to the Division office, where yardage computations are completed, the drawing inked in, and the entire plans finished with the exception of the estimate of quantities and the culverts. They are then returned to Madison accompanied by a statement giving information relative to any specal features of alignment and grade, and also information relative to the status of right-of-way proceedings and available materials for construction. The plans are checked at Madison, the estimate inked in and the culvert plans prepared. The signatures of the location and design engineers are then affixed, approving the plans, after which they are ready for the approval and signature of the State Highway Engineer. After his signature has been added the completed set of plans, including cross sections and plans of drainage structures, are sent to the Federal District office, where they are again examined and gone over in the field by a representative of the District office and an engineer of the State Highway Commission. Any changes in drainage culverts or in the plans themselves are suggested at this time in a letter to the Madison office, a duplicate copy of which is sent to the Division office for its approval or comment.

If the plans are satisfactory the Federal District office adds a paragraph to this letter authorizing the construction work to proceed, even though the project agreement has not been entered into between the State and the Secretary of Agriculture. This letter of authorization is a very important point in the procedure, as the Federal government will not pay Federal Aid if a contract has been awarded prior to the date of the letter, and it is at this point in the proceedings where some trouble has occurred in the relations between the State and the Federal District office.

The Highway Commission has an agreement whereby it guarantees to deposit a set of plans with the District office at least two weeks before bids are taken, this in order to give the District office ample time to examine the plans and suggest any changes which they deem necessary. In some instances Division offices have been eager to advertise for bids before construction work is authorized and before plans have been completed, with the result that the state has failed to live up to its part of this agreement. A hard and fast rule has been adopted and this should prevent a recurrence of such cases.

The division engineer either approves the suggested changes made by the District office or states his reasons for not doing so. If approved, the changes are incorporated in the plans, and two sets of the plans and of the drainage structures, without cross sections, are sent to the District office to be forwarded to Washington. If the changes are not approved, the differences are ironed out through further correspondence with the District office and the Division Engineer. At Washington the plans are approved, one set being returned to Madison and the other retained for the files of the Bureau of Public Roads.

Agreement Estimate

When the final sets of plans are sent to the District office they are accompanied by one copy of the agreement estimate and two copies of the cost analysis.

The agreement estimate is an estimate

of the total cost of the project, exclusive of right-of-way and the cost of surveys and plans. In most cases the unit prices are based on contract prices, since usually the estimate is made up after bids have been taken, but it is also satisfactory to base them on estimated prices substantiated by the cost analysis.

The agreement estimate may contain the cost of detours and temporary bridges, but must not include any items which are a part of the right-of-way cost or have had any effect on the purchase of the right-of-way. For this reason, when cattle passes are used it is necessary to state definitely whether such structures are a part of the right-of-way cost or whether they are required for drainage purposes, and also to keep obstructions in the form of live stock from the road. However, if a cattle pass enters into the right-of-way negotiations, and if a drainage structure is required at the same point on the road, the Federal government will pay Federal Aid on the cattle pass equivalent to its share of the cost of the necessary structure required to take care of the drainage. The Federal government will pay its share of the construction, engineering, and contingencies not exceeding 10 percent of the total cost of the project, and not including the cost of surveys and plans. In other words, it will pay for engineering on construction but not for the engineering required to produce the surveys and plans.

The cost per mile of the project is shown on the agreement estimate. The Federal government will not pay more than 50 percent of the total cost nor more than $15,000 per mile, exclusive of bridges over 20 ft. span. The cost of large bridges is figured separately, for they always receive 50 percent Federal Aid.

Under the original law the Federal government paid a maximum of $20,000 per mile, but successive laws have reduced the rate first to $16,200 and now to $15,000 per mile. If a road has been constructed at one time with Federal Aid, and later a higher type of reconstruction is contemplated, the government will not pay 50 percent of the cost of reconstruction, but will pay a lesser amount, depending on how much was paid on the original work. For example, suppose that a certain piece of road built in 1918 cost $21,000 per mile. The Federal Aid paid in 1918 was one-third of the cost, or $7,000 (under the old state law). In 1925 it was decided to resurface the road with concrete, the estimated cost being $28,000 per mile. In 1925, however, the maximum Federal Aid available is only $15,000 per mile. Since the Federal government had already paid one-third in 1918, it would pay in 1925 only the balance of two-thirds, which, at $15,000 per mile, would be $10,000. If this had been a new, rather than a reconstruction job, the Federal government would have paid 50 percent, or $14,000 per mile. This should be taken into consideration when planning the financing of reconstruction jobs.

A cost analysis is a detailed statement showing the justification of the prices used in the agreement estimate. It should show the length of haul, sources of materials, freight, and the cost of the various activities entering into the pursuance of the work. In the case of estimated unit prices on force account work, profit cannot be included.

The Project Agreement

If the plans, agreement estimate, and cost analysis are satisfactory, the Federal government enters into a project agreement or contract with the state whereby it agrees to pay the amount of Federal Aid named in the agreement estimate. This figure is changed somewhat, and is definitely determined when the final voucher covering the actual cost of the work is submitted, but the amount named in the project agreement is the amount called for in the agreement estimate. The project agreement is made up by the bureau, and three copies are sent to the state. After being determined upon by the commission it is signed by the secretary and the three copies are returned to the Federal government, which keeps two copies and returns one for the state's files. To the project agreement is attached the certificate of approval of plans and specifications.

Work must be advertised in at least two issues of a trade journal before bids are taken. *The Western Builder*, of Milwaukee, is the medium in which the work of the state has always been advertised. Reprints of the advertisements are sent to the Federal District office and to Washington. When bids have been taken, the Federal office is furnished with two copies of the report of the letting. The bureau has recently ruled that Federal Aid will be based on the amount of the lowest bid unless the Highway Commission gives good and sufficient reasons for awarding the contract to a higher bidder. Furthermore, when bids are taken on alternate types of structures, Federal Aid will be based on the bid for the cheaper type.

This policy has been adopted by the bureau in order to prevent owners of patented types of construction from unduly influencing governmental commissions to adopt types of construction which are higher in cost than standard designs.

Federal Aid contracts are made up in the division offices and are sent to Madison for the necessary approval of the Highway Commission and the Governor of the state. In the future, the State Highway Engineer will not approve Federal Aid contracts unless the division engineer has first certified that the right-of-way has been secured and the sources of materials are known. Furthermore, the approval of the Materials Engineer, Location Engineer, Plan Engineer, and Design Engineer must be placed on the contract, certifying that the plans, specifications, and sources of materials are satisfactory before the contract will be signed by the State Highway Engineer. The Federal office is furnished with duplicate copies of the special provisions, proposal, and bond, but not with copies of the plans and specifications. Standard specifications are submitted at the beginning of each season and the blanket approval of the District office is secured at that time.

In conclusion, it should be noted that the Federal District office and the Bureau of Public Roads have always shown a sincere desire to co-operate with the state department in expediting the passage of the necessary documents to final approval. There is a vast amount of detail necessary in preparing the plans and other papers for 420 road jobs, and mistakes are bound to occur, but the Federal District office has always had a thorough appreciation of the large amount of this detail work, and it has always been found willing to come half way in the adjustment of any difficulties which arose.

PATCHING AND RESURFACING PAVEMENTS AT RICHMOND, IND.

By D. B. Davis, City Engineer, Richmond, Ind.

(A paper presented at Twelfth Annual Road School, Purdue University, Lafayette, Ind., Jan. 18-22, 1926.)

For the city properly to maintain its pavements, it is necessary that complete control be had over all excavations and replacements. If complete responsibility is centered on the city authorities they may then receive the censure for negligence or receive the credit for strict attention. In Richmond, Indiana, such responsibility is placed upon the city by ordinance. The city refills all trenches and replaces the surface with its own force.

In this connection it is essential to good business that costs be kept of all repair work. This may be done effectively by means of the usual work order system. In this way relative costs can be obtained for repairing cuts in the various types of pavements.

The efficient repair of pavements requires adequate equipment and tools. Considerable saving may be effected by using modern methods and modern equipment. For patching, the Richmond street department has an outfit consisting of a Fordson tractor pulling a two-wheel trailer wagon, having a capacity of 2½ cu. yds. This wagon was constructed in the city work shop. The body is of wood, resting upon a low wheel trailer support. The sides of the bed are hinged at the third point, to better facilitate the removal of material when the bed is partially empty. Attached behind the trailer is a tar heating kettle made by Connery & Co. It has a warming rack under the hood for an extra barrel of tar. Two men, the driver and a helper, constitute the working force for each patching outfit.

When an excavation has been made in any pavement and the trench ready for refilling, the city is notified by the one making the service cut. The filling is then replaced in layers and thoroughly tamped. If saturated clay or other soft material is at hand, it is substituted by gravel. This is essential if a firm subbase is to be secured in any reasonable length of time.

In gravel and macadam pavements, after the earth is replaced, the old surfacing material is used on top. Care is used to leave it level with the surface of the surrounding pavement, and not heap it up to allow for future settlement. The trench will no doubt settle somewhat, in which case it should be refilled until it is ready for the placement of the permanent surface patch. To leave a trench heaped high, without adequate red lights, is negligence in this motor age.

In the case of trenches in the business district, where there exist plate glass show windows, no temporary surfacing material should be used which contains particles which can be thrown through the glass by passing action. We have found that a layer of rock asphalt is most effective for this purpose. Its cohesive

character tends to prevent the dislodgement of any loose particles and gives a smooth riding surface while the trench is adjusting itself for this permanent patch.

In placing the permanent patch on trenches in a surface treated gravel or macadam pavement, certain requirements should be met. The top material should be removed to the required thickness of 3 in. If there is a lack of sufficient foundation material beneath this thickness, it is provided in the usual way. For the permanent patch, coarse stone is thoroughly tamped into the trench over which 1½ gal. to each square yard of Tarvia X is uniformly poured. Over this is then spread a sufficient amount of ¾ in. stone chips completely to fill the voids and leave a slight excess. When these chips are tamped into the coarse stone, ½ gal. to each square yard more of Tarvia X is uniformly poured over the stone and especially along the edges of the patch. Over this second pouring, a light layer of coarse sand is spread. Particular care is used to keep the patch level with or slightly lower than the surrounding pavement.

In patching small depressions in surface treated gravel or macadam streets, a somewhat different method is followed. After the depression is thoroughly swept free of all dust and foreign substance, by a steel or stiff fibre broom, a light coat of Tarvia X is sprinkled around the edges of the patch; clean ¾ in. stone chips spread, leveled and tamped smooth. A light weight straight edge is handy to test the finished tamping to determine if it is above the surrounding surface before the tar is poured over it. For a finish, a light sprinkling of sand is spread over it.

Gravel or macadam pavements which have not been surface treated should not be patched with bituminous materials, as these bituminous patches will, after a short while, due to the surrounding pavement wearing faster than the patch, stand up like islands in the street.

Rock asphalt is a material which we have found lends itself easily to patching various types of pavements. It is a material composed of fine sand intimately mixed by nature with approximately from 7 to 9 percent of bitumen. This material has the advantage of being easily stored for future or constant use, without losing any of its inherent qualities or without the need of mixture of other materials with it. We have made use of it for patching both concrete, sheet asphalt and brick pavements.

Depressions in concrete or brick are first swept clean, the surface paint coated with asphaltic cement and the rock asphalt tamped or rolled into them. In this case, the level of the rock asphalt should be left at least 3/16 in. high to provide for the compression which traffic will ultimately give it.

To patch sheet asphalt, the old surface material is cut completely out as in repairing with sheet asphalt. The sides of the patch are made rectangular in shape with the thickness of the old surface cut vertical. After cleaning out all foreign matter, the edges of the old pavement are painted with liquid asphalt and the rock asphalt spread and compacted as for repairing concrete or brick.

To secure smooth jobs it is essential that the rock asphalt be pulverized into as small particles as is possible by means of raking and no lumps should be left on the surface. In cool weather this pulverizing can be materially expedited by warming the material before spreading. Our heater, which was designed by the street commissioner, is a double sheet iron pan with sides, made portable by placing it on low iron wheels, with a stack at one end. A small fire is maintained under the heating surface, upon which is deposited the lumpy rock asphalt. Here, an attendant keeps the material stirred with a rake until the lumps are all broken when it is wheeled or shovelled into place in the patch. The warmed material resembles sheet asphalt surface mix, drawing and full of life. Constant stirring will prevent any liability of burning while warming.

Cuts made in brick pavements are replaced with brick. A substantial foundation composed of 6 ins. of Portland cement concrete, reinforced with wire mesh or rods is laid 3 ins. wider than the dug trench. This is to furnish support for the slab. Upon this is placed the sand bed and the brick in the usual manner. The joints are filled with asphalt or tar.

Cuts made in concrete pavements are likewise replaced with concrete. Formerly this was supposed impossible, but now is done very successfully if but a few details are observed. The edges of the old concrete are thoroughly cleaned with water, using a wire brush. This cleaning should not be slighted in any respect. A thin paste of rich mortar is then brushed over the cleansed surface with an old broom. Before the surface of the

edges have dried, the concrete for the bulk of the patch is poured, tamped and finished as for concrete pavements. The important item is to trowel the edge of the patch where it meets the old pavement, in such a way that there will be little chance to ravel. The patch should be cured to prevent excessive shrinkage. The use of quick setting Lumnite cement is fast coming into use for street repairs and is especially suited for patchwork such as we speak of here.

Cracks in concrete pavement should be repaired immediately after they become of such widths that liquid asphalt or tar can be poured into them. When cracks in concrete pavements are not properly filled, traffic soon ravels out the edges, until they become unsightly. Concrete pavement should be thoroughly finished before the cold weather.

Our experience in patching pavements has taught us a few fundamentals which we endeavor to have the workmen follow.

That bituminous patches on unsurface treated gravel or macadam have proven unsatisfactory.

That it is better practice to replace pavements over service cuts, using the same type materials as that of which the pavement is composed.

In pouring a bituminous patch, to use sufficient material to coat the particles without making it "fat."

Paint coat the surface of old concrete or brick where rock asphalt is used as a resurfacing.

Observe the little details of construction which have been evolved from the experience and experiments of others. Do not treat them as being inconsequential or unnecessary. They are the result of the failure and success of others before you. Profit by their mistakes.

Resurfacing City Pavements

Most modern city pavements consist of a foundation and a surface course either constructed separately as with sheet asphalt or brick on a rigid or flexible base or constructed simultaneously as a concrete pavement.

For any type pavement to give continued service it is essential that there exist a well drained sub-soil; a stable foundation and a wear resisting surface. In years past many such wonderful pavements of various types and designs were constructed; returning to the taxpayers every dollar's worth of investment, in real service. But as time progresses and traffic increases, the surface of these pavements wear down; some evenly and some so unevenly that they become unfit for travel. Whence, complying with a popular demand for a new, smooth pavement, the authorities proceed to replace them. In many of these cases, all that is needed is a renewal of the surface course. The foundation may be in perfect condition. It has received the compaction of years of traffic, which is so much more effective than can be secured in any other way.

Inasmuch as economy is the aim of good engineering, it behooves the one in charge to make all necessary investigations to determine the adequacy of the existing foundation, to the end that it might be preserved, knowing that if such can be accomplished, a saving of approximately $1.20 per square yard will be made.

When all information is at hand, the design of the surface for each particular job can then be determined on its merits and becomes purely a matter of the engineer's judgment.

In Richmond, Indiana, we have effected a considerable saving, in many cases, by using a bituminous surface over old worn pavements. This resurface work has come under two heads: that which is done without removing the old pavement surface and that which does remove it.

In our experience we have resurfaced with the following types: Bituminous macadam over old gravel and old macadam pavement. Sheet asphalt over old gravel and old macadam pavements. Rock asphalt over old macadam and old brick pavements.

Preparation of the Surface

Where a bituminous top is to be laid over an old gravel or macadam street from which a portion of the old surfacing is to be removed, great care is exercised in making the excavation. The scarifier teeth are adjusted so that only part of the required depth is loosened at a time; leaving the surface of the old pavement, after the removal of the loosened material, firm and compact.

The practice of the Michigan State Highway Department, where sheet asphalt is being used on old gravel roads, begins with cleaning the old asphalt surface by sweeping, after which it is surface treated with 1/3 gal. per square yard with tar. The tarred surface is brought up to profile by adding black base where needed. The old surface is seldom rooted up and reshaped with new gravel.

Where the depth of the gutter may be reduced, the present surface is first

cleaned and when using sheet or rock asphalt for the surfacing, the pavement is brought to profile by the use of black base. When using bituminous macadam for the surfacing, the small irregularities can be adjusted by an excess of stone.

Soft places in the foundation and service cuts are reinforced by a 6 in. Portland cement or black base slab.

Rock Asphalt Resurface

Rock asphalt is a material which is well adapted for resurface work. It has been used successfully in many cities in this state and others. It is a material comparatively simple to handle and requires a minimum of contractor's equipment.

In the resurfacing of old macadam, it is essential that the rough aggregate in the old surface be exposed by thorough sweeping. This provides a bond for the surfacing asphalt. If a firm, clean surface cannot be obtained, it is often advisable to excavate and replace with a layer of new stone 2½ ins. in thickness, constructed and water-bound as in macadam base construction.

Guide strips are laid 4 to 5 ft. apart and between these the asphalt is raked and smoothed. The strips are of such depth as to provide for 1/3 compaction. Especial care is exercised in thoroughly raking the material and leaving the top of the finished surface free of all lumps. Rolling is done in the customary way with a 10 ton roller, until the surface is smooth and compact.

In resurfacing over brick or concrete, the surface is thoroughly washed and swept clean. The surface is brought to profile with black base after which the cleansed surface is uniformly painted with asphaltic cement by means of an ordinary whitewash spray. If desired, the rock asphalt may be feather edged 5 to 6 ft. from the gutter and also at the car tracks, if any exist. One inch in thickness has proven suitable for this surfacing.

Sheet Asphalt Resurface

Sheet asphalt has been and is now being used quite extensively as a resurfacing over old pavements of all types.

This material is laid in resurface work similar to constructing it on a prepared foundation.

Sheet asphalt cannot be successfully feather edged. It requires a shoulder to be provided in some manner.

Bituminous Macadam

Bituminous macadam has been used successfully over old gravel and macadam pavements and is doing a large service on the state roads. The same methods of construction are followed in resurfacing as in new construction.

SALVAGING OLD MACADAM ROADS

By G. F. Schlesinger, Director Ohio Department of Highways and Public Works, Columbus, Ohio

(A paper read at 12th Annual Conference on Highway Engineering, University of Michigan, Ann Arbor, Feb. 15, 1926.)

The subject of "Salvaging Old Macadam Roads" is one that has received frequent and thorough treatment by highway engineers. While it will be difficult to present many new features in this type of road improvement much that has been said will bear repetition. In addition to the general economics of the subject an attempt will be made in this paper to emphasize the importance of certain features of the work not only in connection with the salvaging process but also as they pertain to the design and construction of the flexible types of road pavement used in construction.

While it may be true that the subject being discussed is an old one there is no question but that it is one that merits the best thought and efforts of the highway engineer of today. Macadam is the oldest of the modern types of rural pavements. This very fact is one reason that its salvaging is of prime importance as more miles of macadam have had to undergo the effects of the phenomenal increase in motor traffic that has occurred in the last 20 years than of any other type of highway. Because of the prominence given the rigid type of pavement in the recent years in connection with a number of comprehensive investigational and research projects, the opinion is abroad to some extent even among some highway engineers, that the macadam pavement is about as obsolete as the "Dodo Bird." No criticism of the concrete pavement or concrete base type of construction is intended and the highway industry is to be congratulated on the developments in rational design methods for this class of pavement due to investigation and research. However, at the same time, it can also be said that the macadam road has been woefully neglected in that it has not received the same degree of investigational attention.

Design and construction methods now ordinarily employed have obtained since the introduction of the use of machinery in its construction. The very meaning of the term "macadam," as applied to modern pavements, has not been standardized. At a recent meeting of highway authorities I was surprised to hear the term applied to a type of construction that in Ohio would be called a traffic bound stone surface or more commonly a gravel road using crushed stone as the surfacing material. This failure to promote improvements in the design and construction of macadam roads can not be laid entirely to the highway engineer but must also be assumed by those interested commercially in the sale of materials used in this type of pavement. Their time would have been better spent in improving the quality of the pavement in which they were interested rather than in attempts to disparage the merits and popularity of a competing type. While it is true that recent statistics indicate that the rigid type has been gaining ground at the expense of the flexible pavement, still there are many miles of macadam being constructed and the great preponderance of existing rural roads are of this type. The last authentic data in regard to rural roads in the United States are contained in Bulletin No. 1279 of the Department of Agriculture which show the mileage by types existing Jan. 1, 1922. At that time there were 87,609 miles of macadam (waterbound, surface treated or bituminous), and 25,610 miles of concrete, brick, wood block, stone block, sheet asphalt, or bituminous concrete. Without making allowances for the undoubted fact that some of the latter type was constructed on macadam base courses, the data would indicate that at that time the ratio of macadam roads to rigid roads was about 3½ to one. Figures furnished by the United States Bureau of Public Roads also indicate that in 1924, 2,464 miles of the macadam type were constructed on the state highway systems of the United States about one-half the mileage of the concrete type. In Ohio about 45 percent of the total mileage of paved roads on the state system is of the macadam type. About 170 miles were constructed in 1925. These statistics are quoted in order to emphasize the fact that the macadam road, due to its prevalence as an existing type, and its continued use in present day highway improvements is now and will continue to be one of the major varieties of pavements to merit the thoughtful consideration of the highway specialist.

The salvage value of a pavement is the value that can be utilized in the reconstruction of the road. Theoretically a road should be reconstructed when it is more expensive to continue its maintenance than to finance its reconstruction. When this point is reached the pavement is said to have attained its "economic life." The economic life of a pavement can be determined if we have accurate data on its first cost, annual maintenance and salvage value. The question then arises as to the design of the reconstruction project. The problem is similar to that of the selection of the proper type of pavement in the case of original construction, although more intricate. The correct method of determining the relative economy of pavements is on the basis of annual cost which consists of not only the road cost, including interest on investment, maintenance, and depreciation, but also the cost of operating vehicles over the pavement. This means that in order to reach a definite conclusion, we should have reasonably correct data concerning the amount and character of motor traffic that can be expected to use the road after it is completed.

Last December we completed in Ohio a comprehensive transport survey of the state road system which included not only a traffic count but also such information as the origin and destination of traffic, character of commodities transported, and weights of trucks and vehicles. This survey was a cooperative project between the Ohio Division of Highways and the U. S. Bureau of Public Roads. I wish to call your attention to one of the conclusions reached as a result of this and similar surveys conducted in other states, namely: the volume of traffic is largely a function of the population tributary to a route. In other words, the road with large centers of population located on it will always receive the largest amount of traffic. Through long distance travel is a small percentage of the whole and is essentially of the passenger car type. In Ohio which is in the direct path of practically all east and west tourist traffic, the quantity of this traffic on our main trunk highways will not average greater than 10 percent of the total. Mr. Thomas H. McDonald, Chief of the Bureau of Public Roads, in an article discussing the Ohio Transport Survey, said, "Highway traffic is predominantly a short distance movement. This is particularly true of motor trucking, but also generally true

of the passenger car movement. Long passenger car trips are quite common, but are small in number as compared with local movement." The Connecticut Transportation Survey indicated that "55.7 percent of all passenger cars have an average trip mileage of less than 20 miles and 81.1 percent of the motor trucks travel less than 30 miles per trip." On a road that is important from the standpoint of interstate traffic and possibly has been selected and named by one of the highway promotional associations as one of its transcontinental routes there is frequently a popular clamor for a high type expensive pavement. There are engineers who have maintained that the same type of improvement should be used on all sections of a road although traffic conditions may vary widely on the same route within a few miles. Such types as macadam may be logical on a certain section of a route even if other sections may require brick or concrete. Any arbitrary selection of type of pavement regardless of cost and traffic conditions can not be justified.

In determining theoretically the most economic type of pavement our computations will be in vain if, due to financial limitations, it will be impossible to construct a section of road long enough to develop the assumed volume of traffic. It is this condition that has caused highway officials to avail themselves of the principle of stage or progressive construction. Centers of traffic flow are connected at once with a type of improvement that is of less permanence than would be called for in the eventual project. The pavement is then added to vertically instead of horizontally as the traffic increases and funds become available. The macadam type lends itself well to this procedure.

The manner in which an existing macadam road may be utilized in new construction is comparatively simple. The old metal if sufficiently wide is used as a base course and additional courses are built above it until a pavement of the proper strength is secured. In reconstructing an old macadam road full study should be made of the advisability of sacrificing the old metal for improved alignment and grades conforming to modern traffic requirements. It is also the economic time to widen the pavement and, if good detours are not available the work can usually be carried on half at a time so as to accommodate traffic. All types of pavement, such as waterbound macadam, bituminous macadam, bituminous concrete, cement concrete, and brick, can be used in the resurfacing process. We have used all of the types referred to in Ohio.

The first question that arises in connection with resurfacing an old macadam road is whether to disturb the existing pavement. The advantages in not doing so are that full benefit of the stabilized condition of the old metal is thereby obtained. The risk in this plan lies in the possibility of not getting the widening of the same strength as the existing pavement. In a number of cases we have widened old macadam road successfully with concrete before resurfacing especially when a high type of top course is used. In widening with a narrow strip of macadam it is difficult to get the proper consolidation with a roller for depths greater than 5 or 6 ins. Two course macadam widening has been successfully constructed in Ohio by using a loaded truck in rolling the lower base course. When resurfacing with a rigid type it is usually advisable to scarify the old macadam, when it requires widening, so as to insure uniformity over the entire width. Many times the surface of an existing road is too smooth to permit of bonding and should be scarified to some extent to remedy the condition. Old macadam roads are usually high crowned and require reshaping by scarifying, although this can frequently be done by the use of wedge shaped courses without disturbing the old metal. The problem is one that requires careful study and at times a complete condition survey, locating in the field the depth and limits of the existing macadam, is justified. The writer did this in one project and found that the time and money spent in a detailed survey and investigation of existing conditions and in the consequent preparations of plans was warranted many times by the resulting economy in construction.

The importance of considering the nature and bearing power of the sub-soil in designing a pavement is now well known to engineers. The value of an old macadam road, even if scarified and spread, as a foundation course that will break up the capillary action of dense impervious clay subsoils is obvious. It follows that the design of the reconstruction project should vary in accordance with the condition of the old macadam if we expect to obtain a new pavement of uniform strength at all points.

Some recent developments in the design

and construction of flexible types of pavement used in resurfacing old macadam roads will next be considered.

Waterbound and Bituminous Macadam

It was formerly considered necessary to use a crown as great as ¼ in. per ft. of width on this type of pavement. We are now constructing macadam roads with a crown of 1¾ in. in 18 ft. the same as for concrete or brick. We are also requiring the finished surface of the pavement so nearly to conform to that required on the plans that it will nowhere vary more than ½ in. from a 10 ft. straight edge applied to the surface parallel to the center line or from a templet shaped to the cross section of the pavement. In order to secure better results in macadam construction we have made certain changes in our specifications and practices.

1. In the case of bituminous macadam (penetration method), we are using bituminous material in the amount of 1 gal. per inch compacted depth applied in three applications instead of two as in former years. For example in a 3 in. bituminous macadam top course we use 1.9 gals. for the first application, 0.8 gals. for the first seal coat, and 0.3 gals. for the final seal coat. Following the application of the first bituminous seal coat the road must be carefully straight edged and any irregularities in the surface not meeting our smoothness requirements must be corrected with bituminous patches. For each of the bituminous seal coats, we require grit to be used at the rate of 1 cu. yd. for each 100 sq. yds. of surface.

2. Another change made is in our requirements for rolling. We now specify on all waterbound or bituminous macadam construction so many "roller-hours" for each square yard of surface rather than the indefinite description of "thoroughly rolling." At least two rollers are required on each contract on that portion of the pavement which is being penetrated and as many more must be provided as are necessary to give each 100 square yards of surface, not less than 10 hours of *actual rolling* after the first application of bituminous material. There are occasions, of course, when sub-grade conditions will not permit strict adherence to the roller-hour requirements but generally we have found that we are obtaining more rolling than formerly under the old specifications.

3. In order to be assured of a depth equal at least to that specified, we are now, in most contracts, requiring a minimum tonnage of stone or slag. We still specify a thickness for each course but state that the contractor shall, if necessary, increase the thickness of the course in order to use the minimum tonnage of stone. It has always been difficult to determine accurately the thickness of a macadam road by field measurements. The use of the tonnage requirement, where it is practicable, eliminates to a large degree the uncertainty as to the quantity of stone necessary to construct a macadam road of given dimensions.

4. We are requiring all inspectors and engineers to determine that the specified quantity of bituminous materials is being used by computation based on actual measurement of the outage and temperature at the tank car. Other methods usually employed, as keeping record of motor tank loads or freight bill weights result in gross inaccuracies and places a premium on "cheating the job."

5. In our standard cross-sectional design of the macadam type of pavement we are extending the base course at least six inches beyond the top or surface course. This practice strengthens the pavement at the edges where the greatest stresses occur under certain loading conditions, and distributes the edge load on the subgrade. We have found by experience that in the past a large part of our macadam maintenance cost was due to breaking and settlement of the pavement at the edges.

6. In order to determine whether the contractor has met our smoothness requirements we intend to run over the pavement with a profilometer machine which will record graphically the variations in the surface finish. We have been using this device on concrete pavements and have tried it out for macadam work with the result that by substituting a shoe for the wheel we have devised a profilometer that will record only the profile of the road generally without indicating each individual stone on the surface.

In macadam road construction and maintenance the difficult problem occurs as to which bituminous material should be used—asphalt or tar. In Ohio for penetration macadam our policy is to use the less expensive. On surface treatment of waterbound macadam we prefer tar for the first treatment on account of its penetrating quality and hot oil for the subsequent treatments if it can be obtained at reasonable figures.

Hot Mixed Asphaltic Surfaces

The results of our fairly extensive experience with asphaltic concrete and sheet asphalt do not warrant us in recommending their general use on rural highways, although there are cases where these types are desirable. Intelligent and competent inspection and supervision in order to obtain good results is of greater importance in the case of the hot mixed tops than of any other type of pavement. It should be said that in general they have been more satisfactory on macadam base courses than on concrete. In line with recent developments we changed our specifications in 1925 for both bituminous concrete and sheet asphalt to require the use of more filler and less bitumen. This will undoubtedly tend to minimize the pushing and shoving evil by increasing the density of the pavement and decreasing the lubricating effect of an excess of bitumen particularly at high temperatures. For bituminous concrete we greatly prefer the "coarse mix" over the old "Topeka" specification. The use of larger stone provides an interlocking effect that will increase the stability of the pavement.

Cold Mixed Surfaces

While, in general, surfaces constructed of natural asphaltic sandstones, commonly known as Kentucky rock, have proven satisfactory on Ohio roads we have experienced some trouble because of the nonuniformity of the material. This surface has the advantage of not waving and being less slippery due to its gritty texture, but if lean in bitumen will pulverize under traffic. No adequate physical tests for determining in the laboratory the suitability of the material have been devised or standardized. With the Kentucky Rock surface course the macadam base has been found more desirable than the concrete. The extension of the macadam base course beyond the top is very important. From our very limited experience with the ready mixed natural rock asphalt in which additional bitumen is added at the plant, we are not ready to approve its use. As Ohio has adopted the policy of not using patented pavements our experience with cold mixed products such as Amesite is limited, although we understand it is being used with success in other states. Emulsified asphalt has also been used in some localities in the preparation of cold mixed surfacing courses with good results.

If either hot or cold mixed materials are used entirely in resurfacing an existing macadam road, the irregularities in the old metal should first be filled in using the proper compaction and then the surface course constructed of a uniform thickness. Another design that is very good with these types, especially where it is planned to widen the existing pavement, is the use of a concrete curb or edging.

Portland Cement Concrete Surface

When it has been decided to resurface an existing macadam with concrete the question always arises as to what value shall be given to the macadam in arriving at the required depth of the concrete. There is need for definite information on this point which at present is lacking. The quantity and character of reinforcing steel, if any, is also a problem that arises. The writer realizes that the recent report of the committee of the Highway Research Board is favorable to its use, but it is also true that their conclusions were based principally on investigations of concrete pavements that were constructed from designs not having such modern details as the longitudinal center joint or thickened edge.

Brick Surface Courses

Where justified by traffic conditions a modern brick surface with soft bituminous filler can be used very successfully for resurfacing old macadam roads. Such a surface combines the attributes of both a rigid and flexible wearing course. A concrete curb should be used and as stated previously a very good practice is to use concrete to widen the old macadam when this is necessary. In Ohio our standard brick surface course is 3 ins. in depth, with asphalt filler, on a sand or granulated slag cushion. As we do not require lugs this permits the use of flat or vertical fiber brick, wire cut with straight sides.

Economy is the watchword of the day and its application should not be confined to private affairs. With our state and federal governments striving to reduce expenses all along the line, highway engineers, who are responsible for the expenditure of such large sums of money should set an example to other public officials in the economy of their operations. It is hard to explain to the taxpaying public that it is economy to dig up an old macadam road that has been consolidated by years of travel and waste the stone along the sides. Excellence in engineering demands that a thorough study of

any reconstruction project should be made before such a procedure is decided upon. Wellington's classical definition of engineering as doing well with a dollar what could be done after a fashion by anyone with two dollars has no more pertinent application than in the case of the reconstruction of an old macadam road. The original investment should not be wasted but should be capitalized and used in the new construction to the greatest possible extent.

TRAFFIC OBSTACLES

By Howard Olson, Engineer, Chicago Regional Planning Association, Chicago, Ill.

(A paper presented at Purdue Twelfth Annual Road School, Purdue University, Lafayette, Ind., Jan. 22, 1926.)

Although the subject of this discussion is "traffic obstacles" I feel certain that a few words about the organization that has come to realize the waste caused by our out-of-date roads and is working to make them into real highways will be interesting and helpful to every county, township and city official and engineer attending this road school. What that organization has done and is doing today is an illustration of how officials doing the same kind of work and confronted by the same sort of problems, but separated by political boundary lines, can pool their knowledge and experience to plan and build highways for present and future needs.

There is nothing complicated or involved in the regional planning idea. It is merely a simple answer to a difficult problem that arises wherever similar or related work extends across political boundary lines. The condition that gave rise to the Chicago Regional Planning Association is the same that caused state highway commissions to be formed throughout our country, namely, a common problem too big for small political units, separated as they are, to handle effectively. The result desired was also the same: a co-ordinating influence to bring about unity in local plans and work with greater vision for future needs. The principle underlying the Chicago Regional Planning Association is a departure from that usually followed in metropolitan planning. It recognizes all officials whose specified duties are related to the work involved. It also included public spirited citizens whose special knowledge or interest will be of value. These men are made consultants and directors of the planning and what special staff is required, work under their policies. The final result is that all phases of the plan receive immediate public support and are assured of realization.

Although the Chicago Regional Planning Association is concerned with all problems bearing upon community development, such as water supply, sanitation, rail, water and air transportation, parks and forest preserves and others, the most important and urgent is highway transportation. The common problem confronting the highway authorities in the many counties and towns grouped around the lower end of Lake Michigan, can be divided into two parts: one, transforming their old-horse and-buggy age roads and streets into more efficient and safe carriers of motor vehicle traffic; and, two, planning every new road for modern automobile traffic with extra width for future widening when traffic conditions warrant.

The problem, of course, is at present more intense near the cities of Chicago, Hammond, and Gary and is likewise near all large populated centers. It does not differ, however, from that which exists in every town in Indiana, Illinois, Ohio, or any other state. Motor transportation is just in its beginning. What is now true around our larger cities will soon be true in our smaller towns. The disease that blights the highways around our larger towns is now, farther out in the country, in its first stages. But, if the highway officials will prescribe the right kind of treatment now, doctor bills and surgical operations on their respective highways will not be half as expensive later.

Traffic Obstacles Defined

The term traffic obstacles in general usage is not limited in its meaning or very definite. In this discussion we will say that any regulation, any regulatory device or any physical feature existing in or along a street or highway that prevents or reduces the economical free or safe operation of motor vehicles is a traffic obstacle.

Why should traffic obstacles be discussed at a meeting of Indiana highway officials and engineers? The most important reason is that decreasing the cost of operating the hundreds of thousands of Indiana motor cars is just as important as decreasing the cost of building and maintaining the highways over which they must travel. In order that we may

gain a rough idea of the importance of operating costs in dollars and cents so that due regard may be given to improvements which will reduce those costs, let us make a few computations.

In 1925, Indiana registered over 650,000 motor vehicles. Assume that each traveled 5000 miles during the year and the cost of operation for one mile was 10 cents per vehicle—an amount found by investigators of the Engineering Experiment Station of Iowa State College to be average. Multiply the three figures together and the total operating cost to automobile owners of Indiana figures out to be over $325,000,000. Now let us suppose that if, throughout the state, all chuck holes and worn out pavements that break springs and shorten the life of an automobile, sharp jogs and many other traffic obstacles were repaired or removed the saving in operating costs would amount to one-tenth of a cent for each mile of travel. The total saving effected would total over $3,250,000.

It is, without question, important to construct and maintain high grade surfaces on our main thoroughfares. One of the objects of this paper is briefly to describe the methods followed by the highway authorities of the Chicago region to raise the quality of their existing paved highways and lower the operating costs.

The Committee of Highways of the Regional Planning Association includes highway officials of the federal government and states, counties and cities of the region. To that group of men, who direct the construction of many million dollars worth of roads each year, removing traffic obstacles is a most important service to the people of the region. It was for that reason that they inaugurated a series of traffic obstacle surveys to be made on the main traveled highways leading out of the City of Chicago to be followed by a campaign pointing out the defects and urging their removal.

Each survey is started at the loop district of Chicago and is carried outward, through the many suburban towns and into the country for a distance of at least 50 miles. From beginning to end roadway widths are recorded and logged along with bottle necks, sharp jogs and turns, rough pavements, unpaved car tracks, railroad grade crossings, narrow bridges and subways, dangerous sections of the road and any other condiitons which slow down or stop traffic or increase the cost of traveling over it. From the notes taken the observer makes sketches of the more important obstacles and shows or describes means of improving each. Strip maps are also drawn showing diagrammatically the variation in width of the roadway, the location of the obstacles and the jurisdictions having control over them. The survey is then reviewed by the members of the committee, many of whom are familiar with local conditions along various parts of the route, and the procedure outlined to bring about the improvement of each obstacle. Meetings are arranged with the local authorities having jurisdiction over each section at which ways and means for effecting the work is decided upon. In every instance the many local officials, good road committees, commercial clubs and newspapers realize the value of the work and give their fullest cooperation in carrying out the details.

The experience of these surveys very often show that the fullest use of our investment in street and highway width is not realized due to different standards or lack of standards used in the various jurisdictions or, absence of a comprehensive plan for the entire route. The most striking example of such a condition exists on the Dixie Highway route extending south out of Chicago. On this heavily traveled thoroughfare a 6 mile stretch of 70 ft. pavement is bottled up with a 40 ft. wide throat at each end. It is easy to see that 30 ft. of the 70 ft. wide pavement gets very little travel. Plans are now under way, however, to remedy the condition.

The obstacles that exist on the more important highways of the region and the congestion resulting on days of heaviest travel is almost unbelievable to anyone not having had the experience of being a part of that congestion. One mile an hour is often the average rate of speed. Typical of these highways and the conditions found on them is Indiana's state road number 43, called the Dunes Highway, which runs through Hammond, Whiting, East Chicago, and Gary around the lower end of the lake to Michigan City. Any summer holiday or Sunday will see this popular road filled with unbroken lines of motor cars extending from the Illinois state line on the west to Michigan City on the east. So close are they at times, it is said, that when a highway policeman in Michigan City holds up his hand for traffic to stop, motorists 35 miles

westward shove on their brakes and come to a standstill.

The cause for the congestion on this particular road is due to the interference caused by the following obstacles recorded in the survey recently made over it: shoulders of loose sand along the country section of the pavement too soft to support cars forced to stop on account of tire or engine trouble; 18 railroad grade crossings in the towns along the route; worn-out, bumpy pavement, sharp turns and corners; a large ornamental square that forces all cars to slow down to twist around its corners; an improperly timed stop-and-go traffic signal; street cars that cut down the width of the roadway; and, unpaved street car tracks. Each obstacle along this route plays its part in adding to the delay and collects its tax in increased operating cost. If usable shoulders were constructed along the country section of the pavement it would be improbable that congestion would be materially relieved. The biggest part of the delay is due to the obstacles existing in the towns along the route.

On other main traveled roads of the region the same general conditions are also true. The causes of congestion lie at the gateways and in the towns instead of on the country highway. It is interesting to note how the location of traffic obstacles have changed since the invention of the motor car. Everyone can remember how the motorist heaved a sigh of relief when his automobile pulled itself out of the rural mud and bumped onto the city pavement. But now it is different. The sigh is of regret as he leaves the smooth country highway and strikes a narrow, worn out city street and is confronted with slow-moving local traffic, numerous traffic regulations and unregulated stop-and-go signals.

The examples mentioned above go to prove why it is good highway engineering and business to locate main highways around towns and cities and build adequate connections to the business centers. It is only recently that municipalities demanded of state highway commissioners and county highway departments that paved roads be focused into their business centers. The pendulum of public opinion, however, is now swinging in the other direction. Business men question the value received from through-traffic trade, but are unanimous in their opinion that anything that adds to the ever increasing local traffic congestion is harmful to their business. To build highways around built up centers is exercising good foresight. Roads must be built to fit modern demands. The automobile which is being designed for faster speeds every year and which is increasing in numbers at an enormous rate, is now the ruling factor in highway location, design, construction and regulation.

Obstacles to Remove

In the interest of safety, economy and free movement of motor vehicles, the following conditions, classed as traffic obstacles, should be removed as soon as possible from existing highways and avoided in the building of new ones:

Local business districts or built up centers where traffic concentrates.

Jogs in alignment due to correction lines or other causes.

Blind curves, intersections and grade crossings. Standardized warning signs and signals effectively placed to serve under the most adverse conditions lessen the danger at these points.

Sharp curves not properly banked and widened.

Curved approaches to subways or underpasses, viaducts, and bridges.

Railroad grade crossings. Until funds are available to eliminate grade crossings on the main highways, crossing planks should be maintained flush with the rails and approaching roadways.

Car line streets. Street cars back up and stop traffic and their roadway pavements are seldom in good condition.

Rough worn-out pavements.

Bottle necks due to narrow roadways, bridges, viaducts, curves and subways or underpasses.

Short verticle curves on summits of hills.

Steep grades.

Highcrowns on roadways.

Slippery road surfaces.

Narrow or unusable road shoulders.

Sign, signal or light posts and buttons located in the center of intersections. They should be placed on the intersection roadway centerlines at the edge of the intersection.

Stop-and-go traffic signals improperly timed for traffic.

Intersections with stop signs in all directions.

Roadways lacking painted centerlines or traffic lanes.

Unstandardized signs, signals and regulations. The Hoover Conference on Street and Highway Safety made up of

representatives from the entire country has made great progress in this direction.

Route, warning and street signs ineffectively placed, out of range of driving lights, not illuminated or invisible at night. With the rapid increase in numbers of motor cars throughout the country, traffic regulation and control is becoming more necessary and exacting. Signs and signals are the means for making regulations and control possible, provided they are so placed to be effective under the most adverse conditions—darkness and a wet or icy pavement. To test the value of a sign system drive under the conditions mentioned above and see if all signs are easily visible and all stops can be complied with without skidding past the point of danger.

TEST ROAD IN ST. JOSEPH COUNTY, INDIANA

By A. C. Mangus, St. Joseph Co. Highway Supt., South Bend, Ind.

(A paper presented at Twelfth Annual Purdue Road School, Purdue University, Lafayette, Ind., Jan. 18-22, 1926.)

The period of useful life of any highway improvement is limited. The time will come when the pavement must be reconstructed. This period of useful life may be longer, under like conditions, with one type of construction than with another. In any case the period of useful life is lengthened by careful attention to the maintenance of the improvement. By proper maintenance the day of reconstruction may be delayed and the period of useful life lengthened, permitting us to have the use of the pavement at a lesser cost per year by distributing the first cost over a greater number of years. However, the time will come when the yearly cost of maintenance will be as great as the yearly cost of the added investment for reconstructing the improvement—then reconstruction is advisable; even necessary.

This is true of the Lincoln highway west of South Bend, a section of pavement in the neighborhood of 13 miles in length constructed in 1915-16. The three miles adjacent to the city were completed in December, 1916, during the freezing weather.

The cost of maintenance and the useful life of a road improvement is a function of the volume of traffic, and hence to draw a comparison, it is necessary to study the location of the improvement with respect to all possible traffic areas and routes. Highway freight traffic has become the deciding factor in determining the structure of a pavement and hence the fact that the aforementioned road is a freight route, must be taken into consideration in determining the kind of material to use in reconstruction.

With highway freight, the scenic beauty or historic interest of a route is of no importance. The minimum ton-mile cost of such transportation is the one consideration. So to reduce the ton-mile cost, the first thought is the choice of routes as to distance. Distance in miles is weighed against ease of traction and the route showing the minimum in the total will be chosen.

It is agreed that highway freight and passenger transportation is already established between great commercial centers. Traffic from Chicago to Toledo, Cleveland and Buffalo pass over this route, traffic from Detroit, Lansing and Jackson enter South Bend over the Ear Trail and there converge with westbound Lincoln Highway traffic and all pass over this particular section, again to separate at Rolling Prairie, a part taking the Dunes Highway through Michigan City to Chicago, the remainder following the old route through Laporte and Valparaiso. This converging and separating of traffic at South Bend and Rolling Prairie is evidence in itself that this section carries the greatest amount of traffic of any section of Lincoln Highway between Chicago and Toledo, hence the necessity of reconstruction.

In the spring and summer of 1925 this section began to deteriorate in alarming proportions. Steel in the expansion joints began to raise out of their moorings to such an extent that it became a menace to traffic. In a great many instances it was necessary to pull them out with trucks. This caused a spalling of the concrete from 6 ins. to 3 ft. especially in that section that was installed during adverse weather conditions of the winter of 1916. During the summer a force of from six to eight men were patching practically half of the time. It became apparent to the Board of Commissioners and myself, that the time had come when the cost of maintenance was greater than the added investment for reconstruction would be.

What material to use, what sort of top to put on this old pavement became a mooted question. Material men, naturally

recommended a top that would require material in which they were interested. Contractors favored that material that would require the use of their particular equipment in installing the pavement. This diversity of opinions and the fact that the state was building a concrete road on the division highway from South Bend to Rolling Prairie, thereby shortening the distance between these two points by two miles, and that the building of said road would have a tendency to divert the heavy traffic from the Lincoln Highway to this new route, led to the conclusion that a test road would be the logical way out of this difficulty.

Accordingly the county engineer was instructed by the Board of Commissioners to prepare plans and specifications for six different types of road, concrete, penetration, sheet asphalt, asphaltic concrete, Kentucky rock and emulsified asphalt. The contracts were let in August and the last section was completed the middle of September, 1925.

The first section of 5 ins. reinforced concrete was built by Reed and Sons of Mishawaka at a cost of $2,150.

The second section was of penetration rolled to 3 ins., built by the Highway Improvement Co., of South Bend, at a cost of $1,100.

The third section, sheet asphalt rolled to 3 ins., built by the Williston Construction Co., of Chicago, at a cost of $1,570.

The fourth section of Kentucky rock rolled to 2 ins., built by the Williston Construction Co., at a cost of $1,430.

The fifth section of asphaltic concrete rolled to 2 ins., built by the Highway Improvement Co., at a cost of $1,400.

The sixth section of emulsified asphalt rolled to 1 ins. was built by the Emulsified Asphalt Co., of Indianapolis, at a cost of $1,150. In mentioning cost, we refer to the contract price, each section being let by contract. The several sections were 500 ft. in length each. In choosing a location, we took a section of highway that was devoid of cross and side roads, thus compelling traffic to traverse each and every section.

What the ultimate outcome will be, we are unable to say, as time is the essence of this project, and it alone will enable us to determine what type of reconstruction will be the best and most practical for future traffic on this particular road.

MICHIGAN ROAD MAINTENANCE METHODS

By B. C. Tiney, Maintenance Engineer, Michigan State Highway Department, Lansing, Mich.

(Paper presented at Twelfth Annual Road School, Purdue University, Lafayette, Ind., Jan. 18-22, 1926.)

Michigan is maintaining a 6,900-mile system of state highways, which are classified by type, approximately as follows:

Gravel	3,700 Miles
Macadam	700 Miles
Concrete	1,400 Miles
Asphalt	200 Miles
Unimproved and other types	900 Miles

The gravel road is naturally our greatest maintenance problem, but this type, when properly maintained and rendered dustless, has excellent riding qualities. The smoothness of the gravel road depends upon the preservation of a thin cushion of loose fine gravel uniformly distributed over the surface. This floating cover, ranging in size up to one-half or three-quarters of an inch, is moved back and forth daily by patrol graders keeping the depressions filled.

Regular corrugations or "chatterbumps" must be removed at intervals by heavy blading and this is best accomplished following a rain when the gravel is workable. We consider it good practice to float the loose cover to the outside edges of the road after rains and leave it there in a ridge for a day or so until the road begins to dry out, at which time it is again floated back over the surface. If the cover is left distributed over the road while wet, it may consolidate under traffic and be lost for floating purposes.

The presence of large stones in a gravel road, near the surface, adds greatly to the difficulty of proper maintenance. Until about three years ago our gravel roads were built under a specification which permitted stone up to 2½ ins. in size, but we are now using a maximum size of 1 in.

The older roads were built with a high crown, making it difficult to hold resurfacing gravel on them. To correct these faults, we scarify the gravel to considerable depth, rake out the larger stones and re-shape with a heavy grader. It is advisable to harrow the road after scarifying in order to bring the oversize stones to the top. After re-shaping, a light resurfacing of clean fine gravel gives an ex-

cellent surface for floating. The cost of this work, exclusive of re-surfacing, is from $60 to $100 per mile and the results are very satisfactory.

It is probably true that in breaking up this old road crust, the road is rendered less stable during the early spring break-up, but we believe that this is more than off-set by the improved riding quality and greater ease of maintaining during the balance of the year. It is not recommended that a road be scarified late in the fall.

The patrol equipment used on gravel roads in Michigan is largely motorized. The two most approved types are the truck with a spring blade attached underneath and the tractor and grader combined in a one-man unit. The truck is operated at a speed of about eight miles per hour, making a round trip on a 30 to 35 mile section daily. This equipment is used mainly for floating loose cover, although considerable cutting of the solid gravel can be done at slower speed, especially after rains. The truck is also used to carry a load of gravel for patching holes and light resurfacing of bare spots.

The one-man tractor-grader operates at a speed of 2½ to 4 miles per hour, making a round trip on 12 to 15 miles of road. It is usually equipped with a rigid blade which does heavier cutting than the truck blade. This type of machine is very efficient in eliminating "chatter bumps" and makes a good combination with truck patrols. The tractor grader is used with a spring blade in some of our counties and this permits greater speed in floating but less efficiency in cutting.

The heavy grader with scarifier attachment, pulled by a 10-ton tractor is used for scarifying and reshaping. We regard this unit of equipment as almost indispensable in the reshaping of gravel roads after the spring break-up and at intervals throughout the season. One unit may be made to do service in two or three counties and the tractor used in the winter for snow removal.

Michigan's large mileage of gravel road presents a serious problem in elimination or reduction of dust. We regard dust control as desirable on roads carrying a daily traffic of 300 to 500, and as almost a necessity for traffic of more than 500.

Our practice in this work has been along two distinct lines:

First. The application of dust palliatives which afford a temporary reduction of dust.

Second. The application of bituminous surface treatments which afford a complete elimination of dust.

Dust Palliatives

As dust palliatives, the two types of material which have been used are calcium chloride and light asphaltic oil. We have found that any attempt to apply either of these materials in sufficiently large quantities to eliminate *all* dust will cause the floating gravel on the surface to solidify under the traffic. This forms a surface crust upon which the patrol graders have little or no effect, and which, under traffic, soon develops into holes. In such cases, it is necessary to scarify the surface lightly in order to restore its smoothness. If dust palliatives are applied more frequently, but in smaller quantities per square yard, they may be made to reduce the dust to such a degree that is not objectionable to traffic and at the same time will not mat the surface or injure its riding qualities. The preparation of a surface for application of calcium chloride or oil involves a uniform distribution of the floating cover and the supplying of cover on any bare sections.

The quantities of calcium chloride recommended for application on roads having ½ to 1 in. of loose gravel on the surface are:

First application—1 lb. per sq. yd.

Second application—½ lb. per sq. yd.

For fairly heavy traffic, a third application of ½ lb. per sq. yd. is usually required. These applications are made at intervals of four to six weeks and a total of 2 lbs. per sq. yd. is usually ample for the season.

The quantities of light oil recommended for use are:

One-fifth gallon per square yard for the first application, followed after an interval of about six weeks by a second application of one-eighth gallon per square yard. The two applications are considered sufficient for a season.

Calcium chloride and light oil not only reduce the dust but conserve the gravel on the road. We find that roads which are constructed of gravel with a sand filler are very difficult to hold intact under traffic in dry weather and this is especially true if the road is built on a sandy subgrade. On these sections calcium chloride is of particular benefit, functioning not only as a dust palliative, but as a bonding agent to prevent raveling and to keep the gravel in a moist and workable condition for the efficient operation of patrol graders.

Summarizing our experience with dust layers, we feel that they are very essential to the proper maintenance of gravel roads; that the formation of a crust or mat must be avoided by application of the dust layer in small quantities and that the road, prior to application of the dust layer in small quantities must be uniformly covered with a thin layer of loose gravel.

The cost of dust palliatives in Michigan is about $300 per mile per year. We do not wish to give the impression that they are applied to all of our gravel roads on which traffic conditions would warrant their use. Our appropriations for this purpose have never been sufficient to finance the treatment of more than about 800 miles of the 2,300 miles which our department would like to treat. Public sentiment, however, is becoming more insistent every year in its demand for dust elimination.

Bituminous Surface Treatments

A further solution of the dust problem lies in the bituminous surface treatment of gravel roads. Our practice in doing this work is very similar to that involved in the surface treatment of water-bound macadam. We have attempted these treatments mainly on gravel roads containing a high percentage of stone, thoroughly compacted, and the nearer this approaches a macadam in structure, the better will be the results of treatment. Full thickness of metal and proper drainage are important factors.

As soon as the ground is free from frost in the spring, the road is shaped with a grader and, if necessary, scarified lightly to eliminate all ruts and holes. Traffic is then allowed to compact the loose material and a true cross-section is maintained by intensive patrol work for a period of a couple of weeks or until such time as weather conditions are suitable for applying the treatment.

The surface is then swept and light tar or asphalt is placed in two applications of approximately a quarter of a gallon per square yard, each. A covering material of pea gravel, crushed stone or slag is used at the rate of 12 to 18 lbs. per sq. yd.

We have used cold application bituminous materials entirely for first-year treatments and the bulk of our work has been done with tars. Last year we gave one road a second-year treatment with a heavier, hot-application material with very satisfactory results. It would appear that the mat thus produced has sufficient body to be carried for a couple of years without re-treating, and at the same time is not so thick that it will wave under traffic.

While the idea of alternating hot and cold treatments on gravel roads has not been thoroughly tried out in our state, we have followed this practice successfully in our surface treating of macadam.

Patrol patching, following the treatment is very necessary. More scaling of the surface may be anticipated, especially during the first year, than would take place on the average macadam road. These small breaks must be patched soon after their appearance, and for this purpose a mixture of coarse sand with the same bituminous materials used in the treatment, is employed. This mixture is made in the ratio of 14 to 17 gals. of bituminous material to 1 cu. yd. of sand. The patching is handled by one man with a wheelbarrow from stock piles along the road or by a small gang with a light truck working from a central yard.

Our experience in surface-treating gravel roads would indicate that they must be treated on an average of three times in four years and the average cost per mile per year over this period, including patching, is about $850. This appears to be economical maintenance for roads carrying a daily traffic of 800 or more, and compares favorably with the cost of maintaining such roads with patrol graders, applying dust palliatives and the necessary resurfacing of gravel.

Michigan had about 122 miles of surface-treated gravel road on the trunk line system in 1925 and it is planned to increase this mileage in 1926. These treatments convert the gravel road into a higher-type surface and eliminate all dust.

We are coming to regard this method of maintenance as a desirable intermediate step between the gravel road and the pavement on heavy-traffic sections where pavement cannot be financed for several years.

In the surface treatment of macadam roads, our department has used both tar and asphalt. Competitive bids are received annually for a season's supply of these materials, based on standard specifications of the A. S. T. M. and the U. S. Bureau of Public Roads. We recommend the use of a light tar, cold applications for the initial treatment and this may be followed, the second year, with a

heavier hot-application tar or asphalt. With hot treatments a larger size of chip used for cover and the finished treatment is sometimes rolled once over to embed the chips. The use of larger chips tends to stabilize the mat and prevent it from waving under traffic.

The hot treatment will normally carry the road for two or more seasons and is then followed with a thin seal coat of light tar or asphalt.

In patching macadam roads, the shallow breaks are given a paint coat of tar and a covering of stone chips. Deeper holes are tamped full of tar cold-patch mixture, which is made up at a central yard and allowed to cure before using.

Hot patching by the penetration method is frequently used where large replacements are to be made.

In the maintenance of an extensive system of concrete roads in the vicinity of Detroit, the method used in maintaining cracks, and joints, may be of interest. The tar for this purpose is received in tank-car shipments and placed in storage tanks at central yards where it is heated by steam coils. From the storage tanks, the hot tar is transferred to portable heaters of 10-barrel capacity, equipped with oil burners and mounted on rubber tires. This portable tank is sufficient to supply one gang for a day's work. The cost of the material by tank-car delivery is much less than by barrel delivery, and a material saving is effected by the fact that no time is lost in waiting for material to heat and there are no barrels to be paid for or handled.

The repairing of asphaltic concrete and sheet asphalt pavements has been carried on, to some extent, by breaking up, reheating, and relaying the old top. This is done by placing the broken pieces in a large flat heating pan, and adding water to prevent burning. The mass is stirred frequently until the water is evaporated and the mixture thoroughly heated and pulverized. Rolling is done with a hand roller. Practically all our asphalt-pavement failures have been failures of the concrete base, due to under-design, lean mixture or bad sub-grade conditions.

The winter maintenance of highways in Michigan is becoming more extensive every year. The first logical step in this work is the prevention or control of drifting. To this end a considerable amount of snow fence has been erected, using mainly the woven picket type on steel posts. Much can be done to prevent drifting on the road by cutting brush and weeds and substituting cable guard rails for the old type of wooden guardrail. The purchase of wide right-of-way and the planting of permanent hedges as wind break will be a development of the future in those sections of the state where land is not too valuable.

In the work of removing snow, a variety of equipment designed to meet different conditions, is in use. The one-way blade plow, mounted in front of a motor truck is the most efficient unit for the lighter snow regions. This equipment will move 6 ins. of snow at 15 miles per hour, and will handle as much as 10 or 12 ins. at reduced speed.

For greater depths the heavy V-plow is used. This type is about 5 ft. high, 12 ft. wide, with wings that extend to a width of 22 ft. It is pushed by a 10-ton caterpillar tractor. The investment in this piece of equipment is not confined to snow removal as the tractor is used in the summer maintenance of gravel roads and on state construction jobs.

In the most extreme snow conditions the rotary plow is being used successfully. This plow throws the snow out for a distance of 30 or 40 ft. each way and avoids, to some extent, the high banks which are the result of using the V-type plow.

In the industrial regions of the southern part of the state the plows are generally started when the snow has reached a depth of about 2 ins. and the plowing is continued throughout the storm. In the northern part of the state where heavy slow-moving equipment is largely used, this policy is impracticable and there are short periods of time during which the roads are blocked.

THE SELECTION AND USE OF HIGHWAY MAINTENANCE EQUIPMENT

By H. J. Kirk, State Highway Engineer, Columbus, Ohio

(Paper presented at Twelfth Annual Road School, Purdue University, Lafayette, Ind., Jan. 18-22, 1926.)

The Purchase of Equipment

There are certain things fundamental to success in buying equipment and above and before them all the public official who buys the equipment must be honest.

Salesmen sometimes become over-zealous. Many are willing to spend five dollars to make ten any time. There is no great harm in accepting a cigar or a luncheon now and then, but elaborate en-

tertainment and junkets, with lots of joy thrown in at the salesman's expense. compromise those accepting them and may become equivalent to accepting a bribe. Remember all these things must be added to the selling price.

The public officials having the power to decide on the purchase of equipment must, therefore, be honest. They must also frequently, and with definite finality, be able to use that little word of two letters pronounce "no"! This quality is sometimes called "guts." In Boston they would say "Intestinal Fortitude."

The third prerequisite to successful purchase of equipment is accurate knowledge of what is best to do the job planned. This is chiefly a problem of fact finding; facts about the job and facts about the equipment.

With all due respect to the salesmen present, I might say that in purchasing equipment I place very little weight on the salesman's wind-jamming. Outside of those here present I do not know of any good equipment salesmen. Generally they have had no practical experience with the line they are selling. They have memorized a sales talk. That is all.

There is a good reason for this state of affairs. On account of the rapid change in highway conditions and allied industries, what is up-to-date today is out of date tomorrow, and there are few salesmen who are in a position to have a fundamental knowledge of the line of road machinery they are selling. My own decisions, therefore, have been based chiefly on interviews with contractors, superintendents and other men who have actually used the equipment in question.

The ideal way to buy materials or equipment on public work is first to draw up detailed specifications, and then receive sealed bids from those able to furnish.

Take the case of materials such as stone, gravel, tar and asphalt. We have specifications in great detail on these. We can take bids and make awards on the low price. It is easy to make tests and see that specifications are met in all particulars.

In the matter of equipment, however, we have no specifications even for small tools that will permit us to take bids and buy on prices. And when we come to large equipment this is a still bigger problem.

Take the matter of motor trucks for example. Suppose you want to buy a two-ton truck. About the best you can do is to make a few general requirements as to power, capacity, body, tires, etc., and ask for bids requesting that detailed specifications be submitted with each bid. You can get a score of truck manufacturers to quote you a price and each will claim his is the best buy at the price. No two trucks will be exactly alike and there is much ground for difference of opinion as to the best "buy." It is obvious that under these conditions low price can not be the controlling factor, because the price each quotes is for a different article. But the public official has to satisfy himself which offer best fits his needs.

This is the big difficulty in the purchase of equipment. The greatest help is a thorough knowledge, not only of the equipment, but of the job it is going to be called upon to do.

Organization for Equipment Repair

This subject of organization for equipment repair I shall discuss chiefly as it concerns a state highway department.

Five or six years ago the various State Highway Departments had turned over to them by the Federal Government large quantities of road building equipment, particularly trucks.

This necessitated facilities for receiving, storing and distributing this equipment. Practically every state had to arrange for a central garage and storage depot.

Some state highway departments are still maintaining these central garages, others are decentralizing this activity. The tendency is to provide garages more or less elaborate for equipment repair in the several districts or divisions into which the state is divided, depending upon the quantity of machinery operated. I have heard arguments for both plans and my own opinion is that the best arrangement is the abandonment of the centralized system of repairs for the whole state and organizing for this by districts over the state.

Practically all the war materials are distributed and there is no longer a need for large storage depots in the states. Ohio maintains a small garage at the state capital for repair of central office cars only and other special operations requiring a machine shop.

Each repair center should have installed a system of cost keeping, simple but effective. An examination should frequently be made to determine whether repairs are becoming expensive. Excessive up-keep may be due to poorly de-

signed equipment, improper care by the operator, or the fact that the equipment is on work for which it is not fitted. When the cost of repairs begins to run excessively high the time comes when the equipment should be traded in on new equipment or sold for junk. The disposal of junk or useless equipment on public work is always a source of trouble. Even though it were possible to get angels from heaven to take charge of its sale, yet someone would find fault. The best policy I have found is wherever possible to trade in old equipment as part of the purchase price of new equipment.

It pays to take good care of equipment. Too much equipment is left out in the open, exposed to the weather, and at the mercy of every thief. Adequate storage should be provided during the winter months. Frequent inspections done should be made during the working season and complete overhauling should be done during the winter season. It costs a lot to have a machine break down during the working season, and no money is better spent than in the forestalling of breakdowns.

Service by the Manufacturer

Last week I attended the meeting of the Mississippi Valley Conference of State Highway Departments in Chicago. The Maintenance Group Conference report indicated great disgust at the service at present being given by road equipment manufacturers.

There is much dissatisfaction at hold-up prices for parts and poor service on repair part orders.

Some companies send out a field man. In some cases this fellow thinks it is his chief duty to get the State's mechanics drunk. This is the exception, but it shows what a distorted idea some manufacturers have of what is meant by service.

I believe it is good business for the road equipment manufacturer to send out a competent service man, not a salesman primarily, but a mechanic with much practical experience and good judgment.

Every manufacturer knows that low prices and big profits lie in quantity production. Hence he designs his equipment to meet a general need. His machine may not fit a particular job. A good service man can often suggest a slight and inexpensive change that will make a satisfied customer. He will thus be a help to the manufacturer and the customer as well.

My own experience is that often the engineers who design machinery are too "uppish" to heed a change suggested by either their own mechanic or outsiders. In other words they do not know enough of the kind of work the machine has to do. Many ridiculous examples of this could be cited, but I will give only one.

I recall a distributor for applying asphalts and tars put out a few years ago. The pump which must be called upon to carry liquids with a temperature up to 300 degs. F. had its bearing equipped with grease cups. Of course the grease melted out in five minutes after starting the heating burners.

A Division Traveling Mechanic

Where much work is being done and a large amount of equipment is being used my experience has been in Ohio that a traveling mechanic for a district or division can save his salary many times over.

Many times the engineer in charge of maintenance is not mechanically inclined. Many times all his time is taken up with other organization duties and he can not give the specialized attention that equipment needs.

Recently I stopped along the road to inspect a motor patrol grader. It had not been greased for a long time. Bolts were loose. It needed a general overhauling. The operator was careless. The superintendent plead ignorance. The grader was ordered into the division garage for repairs. A traveling mechanic, a fellow who is a hard worker and can be trusted, can do a wonderful amount of good in watching cases of this kind. He can spot idle equipment and send it where needed. He should be in charge of the division garage. He should have power to discipline anyone found abusing equipment in any way, even to firing careless operators.

Standardization of Equipment

There are many reasons for standardizing equipment. With but one make of truck in a district the truck drivers and mechanics learn how best to operate and repair it. Better service can be given because less repair parts need be carried to take care of all needs. I must say, however, that this is an ideal hard to realize on public work, especially if you have several firms manufacturing the same kind of equipment in your state.

Recommendations on Equipment

It is with great hesitancy that I take up the matter of making detailed recommendations on equipment. The thing that makes road work fascinating is its variety. Because topography and climate

varies everywhere so do road problems differ in their character and the nature of the equipment best adapted to their solution.

In many of the things I am about to say you may not agree with me, because you have in mind one set of conditions and I another; I, therefore, would ask that caution be used in following out the recommendation I am about to make.

I do not intend to give free advertising any more than I can help. Therefore, although I am perfectly willing to answer any questions you may ask, I must place this condition—that I will not here publicly indicate a preference between particular machines by name. If any of you care to talk with me privately I will express my views, frankly, giving the reasons for my opinion.

Grading Equipment

Many states are carrying on a program of state construction which is closely allied to maintenance work. In Ohio we completed 823 miles of this sort of work in 1925, and it has met with great popular approval. This operation has been carried out in outlying districts and the poorer counties where travel is not heavy. If such communities had to wait for $40,000 per mile roads they would be in the mud 25 years hence. We have given them all year roads at an average cost of $3,000 per mile. The old road has been widened out and minor relocations made. Repairs have been made to bridges and culverts. The old road metal has been salvaged and local materials used wherever possible. On account of a large program outlined we have found it economical to purchase heavy equipment. This stage construction grading merges into gravel or traffic bound macadam maintenance. For grading operations we have found the following combinations of equipment most satisfactory.

1. In hilly country, 10-ton crawler type tractors worked in pairs, one with a 12 ft. blade and the other immediately following with a 10 ft. blade grader. On this sort of an operation we prefer the leaning wheel type of grader because it is free from side slipping, it moves the earth higher and is more easily and quickly pulled out of the ditch. We prefer the track laying type of tractor in all cases because it is not so apt to tear up the road surface or get mired in bad places.

Under certain conditions in hilly country we are using gasoline shovels with ¾ cu. yd. buckets on crawler type running gear.

I look upon the gasoline shovel as one of the recent outstanding developments in road building equipment for rural highways. There are several good shovels of this type on the market. It is far better than the old time steam shovel for light shovel work because of its lower operating costs. Where frequent moves are necessary there is no bother with water lines or fuel transport problems. In coal mining communities and oil well districts there is no trouble with bad water as with the steam boiler on a steam shovel.

You are familiar with wheel and slip scrapers, the latter for short hauls on small jobs and the former for longer end hauls. The wheel scraper, however, is not well adapted to stage construction operations because there is rarely room in the ditch for it to load, except on relocation.

2. In rolling or flat country other types of equipment have proven efficient. Where cuts are long and frequent turns are not necessary we have found the small model of elevating grader most valuable. With a sufficient number of trucks, Fords with gravity dumps are good, it will move an enormous amount of material at a small cost.

Under certain conditions I have never seen anything quite so efficient as a small elevating grader for cleaning ditches.

Roadbed Maintenance Equipment

Here again the type of equipment depends upon the topography. In Ohio we have everything from the flat plains, a century ago the black swamp of northwestern Ohio, to the hills of southeastern Ohio which are as rugged as some places in the eastern states called mountains.

In southern and southeastern Ohio we are bothered with slips and slides. The road may slide away or a hill may slip down on the road. It is too expensive to move in a shovel for this sort of small work, and it is agonizing to watch a gang of men shoveling this earth into trucks by hand.

No piece of equipment has proven more valuable for this sort of work than a small crane with clam shell bucket mounted on a truck. We own a number of these in Ohio, and while we have some of the half circle swing type and some with the full circle swing, we much prefer the latter for moving slips and slides. Our principle reason for this is that we work with the road open to traffic and

the road need not be blocked with the full circle swing.

A small ditcher originally designed for cleaning farm ditches which will do light cleaning has appealed to me as a good tool, inexpensive and valuable for back slipping and other operations where the superintendent or engineer gets gray haired watching laborers wasting their time.

The one-man motor patrol grader is a valuable piece of equipment for shaping up shoulders.

Cutting Weeds

The best job of grass and weed cutting is done with a farm mower having a 6 ft. cutter bar that will cut at any angle between 45 deg. above or 45 deg. below horizontal. A machine of this kind pulled by a good team driven by the owner who lives along the road is the best combination for a good, clean economical job of weed cutting that has ever come to my attention.

The trouble is, however, that few farmers have such a type mower and also they may be busy at other work when you want your weeds cut.

We have used several types of cutter bars attached directly to Fordson tractors. We believe, however, that the special highway mowers preferably with cutter bar that can be raised or lowered 45 degrees from the horizontal pulled by a steam or tractor and operated by a separate man, gets the best job. A team will get into places a tractor can not, thus reducing to a minimum the work which must be done with scythes by hand.

Gravel and Traffic Bound Macadam Maintenance Equipment

I refer here to gravel or stone roads maintained by dragging. There are two problems to be solved in this operation: (1), keeping the surface smooth and, (2), replacing surfacing material blown away.

In the matter of keeping the surface smooth there are many ideas. Here again this may be caused by varied conditions such as different gravels and stone, and also difference in the volume of traffic. I do not know of any one piece of equipment that will keep a gravel or traffic bound macadam road smooth. If a thin layer of gravel or stone can be maintained over the surface much will have been accomplished. High speed rubber tired traffic rapidly throws the material to the sides of the road leaving the center bare and in condition to go into put holes. The loose material should be kept constantly thrown back on the center of the road. The best tool I have ever seen for this purpose is the spring grader blade mounted on springs and turned to the road surface as a razor blade is to a hone. We used to mount this type of blade on trucks received from the government and still have many so utilized, but the trucks are rapidly wearing out and we are now using the same kind of blade in place of the stiff grader blade on the one-man motor grader.

This spring blade carried along the road at 10 to 12 miles per hour will do a very good job of throwing back to the center of the road and covering the surface with a uniform layer of loose material.

But this sort of an operation is not enough. The large sled drag is indispensable, if you are to get a smooth riding surface. As compared with the grader blade it is the same as the carpenter's plane compared to a draw knife. These sled drags should be used every few weeks and when the surface is in proper condition to do the most good. With proper equipment and correct manipulation of materials a gravel road can be made smooth for riding as any hard surfaced pavement ever built, and much smoother than the average built in the past.

Now let us consider the matter of replacing surfacing material. This problem may be handled in three ways.

a. It may be shipped by railroad from commercial plants.

b. Gravel may be obtained from gravel pits or stream deposits.

c. A local stone quarry may be used to supply stone.

Where materials are unloaded from railroad cars, car unloaders and trucks are necessary equipment. In Ohio we contract with trucking companies for this sort of work. Bids are taken for material per ton spread on the road.

The working of local gravel deposits is so involved in local conditions that each location is a problem in itself.

One very satisfactory piece of equipment for this sort of a job is a certain one unit gravel crushing, screening and loading plant. Material is delivered to a belt conveyor usually by a drag line. It is then elevated to screens and oversize material turned into the crusher. It is finally delivered to the waiting truck by means of a belt conveyor. No other piece of equipment equals it in performance, compactness and portability.

Recently developed equipment valuable in gravel pits includes belt conveyors, bucket loaders and truck mounted clam shell cranes. Drag line outfits can be used in many places to good advantage, depending on the depth, area covered and over-burden of the gravel deposit being worked.

In some districts where there is no gravel it is possible to crush and screen local limestone. For a small operation an air compressor operating drills is very handy. For larger operations a well drill should be used for blasting holes. The best quarry arrangement is where the crusher can be placed much lower than the quarry floor. The stone may then be chuted to the crusher platform into the crusher and then elevated to the storage bin. I have seen cars with small gauge track and Fords with gravity dumps used to good advantage on local limestone quarries, depending on conditions. We prefer the gyratory type of crusher generally because it produces a more uniform size and has low up-keep.

Bridge and Culvert Work

Bridge and culvert maintenance is sometimes sadly neglected, particularly the repainting of steel bridges.
as against hand methods. I believe there

I have heard arguments pro and con on the use of sand blast for cleaning and the air brush for painting steel bridges, is a place for both. Inaccessible places are best taken care of by the sand blast and air brush. On the other hand a better job is obtained with the paint brush on accessible surfaces. Much depends on the personal skill of the operator. The paint spray frequently causes damage to the finish of passing motor vehicles. Both methods are being used with success.

In each division in Ohio we are employing one, and in some divisions several gangs as part of our maintenance organization, exclusively on the extension of small culverts and the rebuilding of small bridges. Concrete bridge work requires experience and skill. We use concrete mixers mounted on rubber tired trailers, easily portable, and other equipment necessary on this sort of an operation.

We have found the cement gun a valuable unit for economical repair of certain kinds of masonry abutments. Bridges and culvert maintenance is so different from other road work that I believe it deserves special attention by experienced men with adequate equipment.

Macadam Maintenance Equipment

The largest piece of equipment used on macadam maintenance is the motor truck tank distributor for applying bituminous surface treatments. There are several good distributors on the market that will handle materials, both for cold and hot application. The tendency has been to simpler design, less pipes, etc. A recent development is the use of a separate motor for pump operation. This is especially valuable on penetration work and in hilly sections.

For cleaning the road surface a good Fordson sweeper combination is on the market, built stronger than the old horse-drawn sweeper. This design has the broom back of the operator which is a distinct advantage.

The biggest part of macadam road patching today is with bituminous materials. Tilting drum type mixers with skip are preferred for mixing stone and bitumen because they clean easier.

I have found the small Fordson type roller, of which there are several makes on the market, a labor saver in places where there is extensive patching. It can be easily loaded into a truck and cheaply transported from job to job.

Heating kettles of two barrel capacity are well adapted for macadam maintenance. We buy them in all cases equipped with oil burners. This feature is well worth the extra cost as it eliminates much loafing for the kettle to heat up. There have been some accidents due to exploding gas from heaters, but this can be avoided with proper care.

Equipment for Repair of Concrete and Brick

The air compressor with paving breaker is the most recent development for concrete road repair where replacements are necessary. This applies to all concrete base pavements.

The same recommendation for heating kettles as mentioned under macadam applies to concrete and brick pavement repairs.

A special air hammer mounted on wheels is the best tool we have seen for taking down high spots or raised points on concrete pavements. We have seen an attachment for Fordson tractors with revolving grinding wheel, but this is not nearly so fast as the air hammer recently developed.

On account of shortage of time I omit here the discussion of several other classes of equipment such as for snow removal, proper machinery and tools for garages, etc.

Outstanding Equipment

I will name what, to my mind, are some of the outstanding pieces of equipment valuable on maintenance work.

There is the Ford truck. It is low in first cost. In many places it could replace some of the war time junk still called trucks at a fraction of the operating cost. On hauls up to 3 miles it is the most economical. Over that it fails. On hills and in hard going the cooling system fails. In Ohio we equip all new Ford trucks with auxiliary transmissions. There is no use overlooking the low cost of repair parts and the ease of handling Ford trucks.

I feel like saying a word here for the small elevating grader, particularly for the operation of widening old road beds and cleaning ditches.

The one man power grader is a comparatively new development that has great possibilities.

The belt conveyor for car unloading and the cheap handling of materials out of gravel pits is a good tool in first cost and easily portable.

The truck mounted crane is a great piece of equipment. We have used them for moving slips and slides, earth excavation of various kinds, handling materials from cars, gravel pits and creek beds, pile driving, handling culvert pipe and other of the numerous jobs a crane can do. Such a crane does work too small for a large shovel and is easily and quickly moved from job to job.

The use of the air compressor as a source of power on road repair operations has great possibilities, limited only by the development of auxiliary tools. Today we have paving breakers, air brushes for cleaning and painting, the sand blast, the air hammer, for smoothing concrete, air drills for light rock work, riveting tools and no doubt other tools will be developed. It meets one of the fundamental requirements so desirable in road repair equipment, it can do many different kinds of work.

The Motor Truck on Road Repair

There is a big place in my opinion for the Ford truck for hauls up to 3 miles, hauling men and light patrol work.

For general maintenance work I would buy a 2 or 2½ ton truck, pneumatics all around, dump body and hydraulic hoist with full cab.

On long hauls over good roads bigger trucks may be advisable, but I believe this sort of work is more economically contracted. We can not afford to buy these trucks in Ohio when haulage contractors will do the work for less than our costs. The best trucks in this class, bar none, in all-around reliability and freedom from break-downs are the "Class B" Liberty trucks supplied to the States by the Federal Government.

New Equipment Needed

Road equipment is much better designed than it was a few years ago. Teams formerly were used much more extensively, but they have been largely displaced. Much trouble was experienced a while back attempting to use tractors to pull machines designed for teams. And while we have little of this sort of trouble today, there is much room for improvement in other ways.

The chief source of trouble occurs where the manufacturer's engineers do not have the practical knowledge of the work of the machine.

Motor truck bituminous distributors need wider tires on penetration macadam work. Better heating facilities, in the way of a burner made of metal of higher heat resisting quality and designed to secure more complete combustion will save much valuable time now lost. Provision should be made in the design to reduce piping to a minimum and to automatically heat all pipes, even the spray bar.

A street sweeper should be provided of more sturdy design than the ones still being manufactured and never intended to be pulled by tractors or moved at high speed from job to job.

In general a better running gear is necessary on maintenance equipment because it very frequently must be moved and moved in a hurry. This applies to belt car unloaders, tar kettles, concrete mixers and other machines.

We are doing more and more maintenance work in the winter. This is because our roads are used more in the winter than formerly. Note the popularity of the closed car and the increased use of the motor truck in business. This means that we must provide better against cold for the operators of trucks, graders, etc. For the same reason I favor closed cars for all engineers and superintendents who must drive long distances in all kinds of weather.

There is a big field for new equipment on maintenance operations on rural highways.

A central mixing plant lay-out for mixing cold patch bituminous materials would meet a popular demand.

A central mixing plant for concrete road repair would fill a need. It could be designed to set up at the railroad siding, using say a 10-L size mixer on rubber tired trailer, batch boxes and belt conveyor to charge the mixer.

Where the mixer must be placed on the road and half the road kept open to travel on concrete road repair a mixer is needed that can be turned 90 degs. for loading the skip on the pavement.

Half the labor in erecting guard rails is in digging post holes. I would suggest that in view of the many attachments made for use with a Fordson such a post hole digger might be made, using the tractor for power. In fact I know of one now being perfected. Another solution would be to design a post-hole digger to be run off an air compressor. At my suggestion a certain company spent some effort on this problem, but so far without notable success.

Conclusion

Last week in company with an Ohio road contractor I stood on the balcony of the Coliseum at the Road Show in Chicago. We were looking down on a magnificent array of road building equipment, estimated to be worth $3,000,000. I remarked to him, "What would some of the old "side-walk" contractors say if they could see this?" The contractor ever with the point of view of his tribe replied: "I am wondering what a man would do who had it on his hands with no work to do." The moral of this story is:

"Don't tie your money up in expensive equipment unless you have work for it to do."

Contractors must obey this rule or go out of business. Public officials must follow it or be kicked out of office.

The justification for buying equipment depends on the economy of what it will do as compared with other methods.

On public work and particularly on highway maintenance work there is another very good reason for the extensive use of labor saving equipment.

Most of all road repair operations are carried on with the road open to traffic. The work is done under the eye of every passer-by. The farmer, not very prosperous these last few years, is especially critical. Every time a laborer, even for a moment, rests on his shovel handle, several heavy taxpayers see him. And you know what happens. We depend upon public opinion for the support of an adequate highway program. I am, therefore, in favor of keeping the number of public employes on rural highways down to a minimum. Labor saving machinery is the best way to do this.

The volume of road maintenance and repair work on highways is growing by leaps and bounds. It offers a field of opportunity for the road equipment manufacturer and the road contractor.

The greatest loss in connection with equipment generally is the loss when it is not working. The purchaser of equipment, therefore, be he public official or private contractor must know that he has superintendents with ability and finances adequate to make that equipment earn more than it costs. I say this because no equipment can take the place of the man who has good judgment, initiative and energy to do things.

DISCUSSION ON DISTRIBUTION OF GAS TAX AND AUTO LICENSE FUNDS

(Editor's Note: Students of the problem of road and street financing are devoting much time to the study of the best way to divide the revenues from gasoline taxes and automobile license fees between the State, its counties and its cities and towns so as to do the greatest good to the State and all its inhabitants in the long run. The problem is not the same in all states. For example, some states can bond for state highways while others are not permitted to do so by their constitutions. A state that bonds is not so dependent on motor revenues as one that does not. Thus local conditions affect the proper solution of the problem. The arguments advanced are everywhere much the same and one of the fullest and best discussions of this general subject developed at the 1925 meeting of the League of California Municipalities. The discussion is reproduced here as reported in "Pacific Municipalities," the official journal of the League. The arguments there used will help public officials elsewhere in their analysis of this subject.)

The Chairman:—We will go on to the subject of the symposium on the gasoline tax and motor vehicle fund. I think that we ought to have a very good and full discussion on this subject this morning. This is the last session that we are going to have and I believe that we are all interested in what share of the gasoline tax the city should get. The subject is open for discussion.

Vice-President Wheeler:—I was not prepared with anything in particular, but, in order to start the discussion I will say that we had this matter up at the Legislature, that is the committee did, but I have forgotten what became of it. In the county of Los Angeles we are not particularly troubled with that problem, for the reason that the Board of Supervisors allowed to the cities a portion of the tax, I could not say just offhand, and I do not know as it is any fixed percentage, but it is based upon the necessities of certain communities to receive that amount of money. And I will say that we have had many arguments with the Supervisors before they took that course, and the result of it was that the city of Los Angeles itself is getting a very fair proportion of the tax money. In talking this subject over this morning with the delegate from Delano, I noticed that his argument is the same argument of practically every city: that the cities should receive back a portion of these funds, as it is in the cities where a large portion of this tax originates, naturally there being more automobiles in the city than there are in the country, and that the city should receive back an equal portion. We did not look at it that way. We (the cities) pay probably two-thirds of the whole gasoline tax of the State of California and yet, after paying two-thirds of that tax, we do not believe that that tax should, in its entirety, go back to the municipalities in which it is collected. Why? Down town, in a residence street where property is worth $10,000 a front foot, paving costs no more there, or practically no more, than it would out in the country along side of a piece of land held by some farmer who is simply existing, a farmer say who owns three or four acres along the highway, and the same amount of tax there would absolutely confiscate that man's land. He could not raise another onion or another potato if the street were paved with gold brick. We did say this: in the first place that, if it were not for the outside community, that is the rural community, the producing community, if that were taken away, in 30 days' time all of us fellows would be down here along the beach digging clams with a stick in order to make a living. And that is absolutely true because we are not the producers of those things that human beings must have in order to live. They come from the rural districts. There life has been made more tolerable by the advent of the telephone and the auto, and now the radio and many of those things, the parcel post and the rural delivery. But I will tell you that no community can stand or become great or rich or powerful, and remain so, unless they have a back country around about them that, first, is productive, and then properly taken care of, and unless those primary producers of those things which we must have today receive a fair share of the public attention. Now, we say this, and this is the plan of the Supervisors in our county: in the first place, we go to them and we say approximately how much they have turned in to them, so many hundred thousand dollars this year for instance from the tax. We know about what that is. It was formerly my business, as Chairman of the Public Works Committee of the Council, having in charge all the public works, the streets and all those things, to find out what this amount was. And then we laid out a plan of action, and, mind you, friends, this was done also with the aid and assistance of the regional planning commission and also the city planning commission. First, we picked out certain highways, certain streets leading to the outside that were highways, or continuation of certain highways or roads that led into the city from the outside communities. For instance the Cahuenga going from Hollywood right over the hill into the Fernando Valley. The land itself is absolutely and utterly useless. You could not raise a goat on it, ordinarily. The only good it ever was used for was when the Mexican army surrendered to General Fremont there. That is the only time it was worth anything. But it is a strategic point, all the travel from Santa Barbara and Ventura and all up the coast, and probably 90 percent of the travel to Bakersfield and Fresno and San Francisco and the northern part of the state goes over the Cahuenga. Those of you who have been over that pass lately know that the steam shovels are working there now and that it is in a bad condition. But, in order to widen the road and make the necessary improvements we could not tax those people abutting on that frontage there for the improvement of that highway. That road is used by many trucks daily, loaded with cement and gravel and rock. And when that road is finally paved it must be of extraordinary thickness and durability in order to stand up under the heavy travel. And

it must be very wide because all the travel of the state, practically, is concentrated right in that narrow part of the funnel and then branching out a mile or so beyond on both sides. And that is only an instance. We have a number of other cases, not quite so bad as that, but important. So we said to our Supervisors: "We are going to open this street, we will put in so much. We believe that so much from the general fund is at your disposal and that part is needed for the pavement of the Cahuenga Pass road, or the road to Whittier or to Pasadena or one of the beach roads. We are building two or three additional roads to the beach and they are nearly completed." And the Board of Supervisors took it under consideration. They say that they will not allow us money which will go into the improvement of a purely private residential street. And I believe they are absolutely right in that respect. They have no right to take money from the gasoline tax or the distillate tax and use it to help to pay for the pavement on Spring Street and Broadway, say, where the value of that property is from five to ten thousand dollars a front foot. If those property owners are not able to pay for the paving in front of their property which, as the last speaker said, has been increased in value by the unearned increment there, in fact society has created those values, it is too bad. We believe that they at least should pay for the paving in front of their own building. But we say in the case like the Cahuenga Pass highway, where there is no taxable property abutting on the road, and which property is not increased in value practically a dollar by the fact that the road is there, and in many cases, people actually move away, they will not stay on a road of that kind, where it is a continual procession of heavily laden trucks going one way and empty trucks coming back, and the empty ones making more noise than the loaded ones do. And so they look it over and they say, "Yes, that is a good improvement." And that is the policy that we pursue. Take the most important arteries, we plan to do them first, in other words to do the greatest possible good with the least expenditure of this public fund. So we are using it, and we are cooperating with the Board of Supervisors in our county. Now, as a member of this organization, frequently the proposition comes up from delegates of some of the smaller towns, in counties where the Supervisors say,

"Here we have a pot of money from the state and we are going to put it out in our particular district," eliminating the municipalities, wherein a large part of that tax originates, from any possible returns from that fund. Now that is wrong. Take for instance the town of Delano where the state highway goes right through for a couple of miles. They say that that highway has been paid for by the state and the people of Delano never paid a dollar except their share of the general taxation. But, on the other hand, just using Delano as an example, there are certain roads coming in there, like the east and west roads across the valley, some of those roads might go through swampy land or hilly land or hog wallow land that is practically worthless. Then it becomes the duty of the Board of Supervisors of that county that they shall pay their share to the municipality or the corporation of Delano, or any other town. They should pay a reasonable share of the improvement of that street that is coming into this municipality, and which is, sometimes, a continuation of the state highway. Now, the practical part of this is that the Supervisors are just as human as anybody else, and a great deal more so at times. They frequently want the expenditure of this entire sum of money and the incorporated cities can go to. Well, we believe that is wrong. I took it up with the legislative committee. We want the state to dictate or require or compel, if necessary, that the Supervisors having in charge the expenditure of this fund, coming as it does direct from Sacramento, for distribution in the different counties of the state; in other words, make it mandatory upon those Supervisors, not that they "may," because if they "may" they "may not," you understand, but to make it absolutely mandatory upon them. Now, what I am going to say next I won't state in figures because that is a matter of fact, that is a matter of good judgment, that is a matter of good citizenship, to be decided under local conditions, and I do not believe that any one really could cover it all. But that the Supervisors shall return to the municipalities within that county, where a large part of the tax originates, or expend for those municipalities money for the improvement of the main roads going to or from those municipalities, and that it shall be cooperative effort with the city engineer of the city council or the town

trustees or whatever is the governing body of the municipality. And the whole thing simply resolves itself into this fact that the Supervisors did not want to loosen up. Why, the people of the state did not pay that tax for the benefit of the Supervisors, that they might build some good political fences and get a lot more votes off in their neck of the woods. And yet that is a considerable part of what they are doing. Now, I am not saying this in all cases, but practically all over the state they tell me that the same thing is true. Why, we believe that the people in the cities are pretty near as good as those that live in the country, as long as they behave themselves. And the only thing that those fellows will respect is power and authority, and we have simply got to tell them where they must get off.

This leads me just to one other point: They will never give up, they will never disgorge until they are required to. And so it rests with this organization, primarily, as an organization representing practically almost every incorporated community in the state. And what is everybody's business is nobody's business and therefore there has been no concerted action outside of what we ourselves have done in this organization. Mr. Locke, Mr. Mason, myself and the president and our legislative committee have been up there and we have talked until we were black in the face. But those Supervisors have a good organization, they have a high-class organization and they seem to have more power and influence in Sacramento than all the incorporated municipalities in the state put together. My point is this: that we are representing these communities, and if this organization properly functions, when you delegates receive word from this organization, furnishing you with certain facts and figures and data and you could simply go to your local members of the legislature, to your senators and to your assemblymen, and say that we, as taxpayers in our communities, do not object to pay a fair and reasonable and a just tax on gasoline, or whatever it may be, but we do consider that we are entitled to some returns, and we want to get behind this bill that is in the legislature, presented by the League of California Municipalities—we do not care who presents it as far as that is concerned—and we want you, as our representative, to do something for us once in a while, and we do not know any way that you can start in any better than doing it for us on this tax.

Mr. Clark:—I come from Delano, the little town referred to by the gentleman who has just spoken. I am very glad to hear the name of our little town spoken of so many times here. We are going to be the center of the raisin industry before many years, and we are rapidly becoming the center of the cotton industry. But I would like to reply to a few remarks made by Mr. Wheeler. I endorse a good many of his remarks. I think it can be said, though, that Los Angeles is particularly fortunate in having been able to get their Supervisors to spend some of this tax money on the city streets. But the fact that they have been so fortunate does not give them reason to lose sight of the fact that there are many other cities in the state that have not been so fortunate, and, therefore, are receiving none of the tax money from the Supervisors. As to the question of how this tax should be divided, there is no doubt but that that is a difficult problem. But the very fact that Los Angeles has gone to its Board of Supervisors and has been able to get a portion of that tax, proves, beyond any question of doubt, that it is a matter that every city is interested in, and it is of enough importance to the state to require the Supervisors to grant the city some of its money, which proves the point that it is only just that the city should have a portion of that tax money, it seems to me, and that Los Angeles realizes that fact that the city should have a portion of that money. Now just what portion is a question, and while I believe that last bill that was before the legislature provided that this tax money should be apportioned to the cities, in proportion to the number of automobiles in that city, the same as is done with the counties at the present time, that system may be wrong. It may be proper that the Supervisors should only allow a certain percentage of this money to go to the cities, and that that money must be expended upon the main arteries. That may be true, and if all Boards of Supervisors were alike you could depend upon them to grant the cities a portion of that money. It would be perfectly right and proper to leave the law the way it is. But inasmuch as we cannot depend upon them always to do that—and now I am not criticizing our Board of Supervisors because we have a very fine set of men and possibly they will grant us something—but I am taking every city of the

state into consideration, and I believe that it will require legislation to make it mandatory upon the Board of Supervisors to grant the cities a portion of that money, and if it can be done by requiring them to spend that money upon the main arteries of the city, that is all well and good. The cities of course, are absolutely dependent upon the surrounding country, but, upon the other hand, we must look at the city's side of it. The rural communities are, more or less, dependent upon the towns and every time the farmers come into town they pass over the main boulevards and thoroughfares leading into town, and it is only right and proper that the people in the cities, who pay a portion of this gasoline tax, should receive a little of it back for the care, maintenance and fmprovement of those streets over which the country people are traveling into town every day of their lives. It seems to me, it is only just and proper that the cities should receive some of this money back, and the only way that we can depend upon getting it, to a certainty, is to have legislation passed which will require the Boards of Supervisors to give us a little of that money.

Mr. Kiernan:—I happen to work practically next door to the Highway Commission of the State of California, and from sitting in at meetings of various public and semi-public bodies in the interests of roads, and hearing the discussions from time to time, there occurs to me this thought, and this is merely a little information that I want to leave with the gathering, and that is this: that the first duty of the Highway Commission of the State of California is to provide this state with a system of trunk lines which will permit travel to and from the various points of importance or interest. Now, it seems to me that there enters into this question of the application of the gas tax fund a factor that we find in city streets once in a while. In fact, we have one instance of that before us right now in Sacramento. The minute you can differentiate between an improvement of local benefit and an improvement of special benefit or an improvement of general benefit, it seems to me that it ought to be an easy proposition to fix the tax or the cost of the assessment, whatever it may be, whether it is assessed against the individual or the corporation or the general fund, that you ought to be able to fix the cost, the equitable cost, of that particular improvement as divided between special or local and general benefit. Now, we have a situation, to demonstrate my point, in Sacramento. Through condemnation proceedings we have given the Southern Pacific Company the right to use a certain street for their tracks, and in order to provide against wear and damage we must put in a much heavier pavement than the average one. The matter was started under the system of assessing the abutting property. Well, after it had gone through, the citizens owning property abutting that street are petitioning for the city to pay a portion of that expense out of the general tax fund, and, in my judgment, the application and petition of those property owners is absolutely fair because the minute the element of general benefit to a community enters into a project of this kind, there is a binding duty on that community at large, and as a whole, to shoulder a portion of that expense.

Mr. Beck:—I will say that we do that here in Long Beach on some of our streets. Certain pavements on certain streets will be for local use only, but where a heavier pavement is necessitated in excess of that used on local streets, you take a 10 in. pavement by way of illustration, it seems reasonable and fair, where that pavement is used for general purposes, that the abutting property owners should not bear all of the expense, and that the city, in general, should pay a part of that expense, out of the city's funds. And where an ordinary street, for any reason whatever, will serve local purposes all right, but where necessity demands that the pavement be wider than usual, for general purposes, the same obligation should apply there. And we have instances where a pavement of 36 ft. would be sufficient for the local use of a particular street, but the pavement was increased to 60 or 70 ft. in width for general purposes, and a heavier pavement installed, and it is my belief that the city in general should pay, from the general fund, a part of that expense. That is somewhat our position here. We are gradually coming to it. I think Los Angeles, in the widening of Tenth street, if I recollect rightly, spent $6,000,000. The city in general, the city council at that time made provision for about $1,500,000 of that $6,000,000 that they were to pay for the widening and paving of Tenth street. They were to pay that out of the general fund, realizing that it was of general benefit to the entire city

and that the abutting property owner should not pay all that cost.

The Chairman:—Any further discussion on the gas tax? The main arteries of both state and county that go through cities should be maintained, partly by funds other than those from the abutting property owners.

Mr. Barzellotti:—I do not know whether that would come within the scope of the gasoline tax, it might, but at any rate it is a big problem of our street improvement. I will make a kind of supposition: take a city like Santa Rosa and suppose that the state highway runs just along the city limits. Suppose the road runs north and south and that the city limits are just along the west line of that highway. The highway is to be improved. The state will improve a strip of the road 20 ft. wide, but it would be desirable to pave the road to its full width, say 50 or 60 ft., whatever it is. Now the question is, would it be possible to use the 1911 Act and the Bond Act of 1915, to assess the property of the citizens along that side of the road which is within the incorporated limits of the city, say on that west border of that side of the road, for the improvement which will be made immediately outside of the city limits? The state highway is 20 ft. wide, and in the case I have supposed it would be desirable to make this road 50 ft. for the use of the city. Now, the question is, how can that improvement be fiananced? The state highway commission will not pay more than the 20 ft. Then it would be up to the citizens to pay the balance. Now, how could the rest of that road be fiananced? Is it possible to assess the property, fronting on that highway, but which is within the city limits, for an improvement to be made outside of the city limits?

Mr. Kiernan:—I can tell you about an actual case in Sacramento. One of our roads runs by a park which is owned by the city. Some day it will be one of the main arteries of Sacramento, and the north line of that road is the city limit on the south side of the city of Sacramento. I proceeded to try to get that road improved, and I found that the policy in vogue was that the Supervisors of Sacramento were ready to go ahead and would improve their half of the road and pay for it, but there must be a mutual agreement between the city and the county authorities as to what type road and what width road should be put down. Well, at that time, it was a transitory stage in Sacramento, that is, we were changing from the commission to the managerial form of government, and we were putting on a very extensive bond program and the city did not feel that they could dig up the money for this improvement, because, as the owner of the park, it was up to the city to pay for the north half of the highway. That is not a state highway but it is a paved road and an analogous situation. But I think that is what you will find in a matter of this kind. The general policy is to spread the expense, half between the city and half between the county.

Mr. Clark:—Right along that line, I think there is absolutely no question but what it depends absolutely upon your Boards of Supervisors. So far as the city levying any assessment upon property outside of the city limits is concerned, I think that would be an impossibility. The city has no jurisdiction on property outside the city limits. All that I could see that could be done in such a case as the gentleman from Lodi speaks of is that if the city wanted to pave such a street, and the Supervisors were not disposed to use a portion of the county funds to make that improvement, the city would simply have to dig down into its general fund and pay for the pavement of that other half of the street.

Mr. Barzellotti:—The highway is all outside of the city limits.

Mr. Clark:—Then the city has absolutely no jurisdiction over it.

The Chairman:—I believe, where a road is a boundary road, partly city and partly county, the city can pave it.

Mr. Barzellotti:—I have been informed that the Act of 1907 could be applied to that very thing. That Act provided for the formation of a district. For instance, we have a street called Cherokee Lane which is on the east limits of the city of Lodi. It is 80 ft. wide. I have paved part of it. The state highway commission will pave 20 ft. of that next year, but that would leave 20 ft. between the state highway pavement and our pavement. The state highway commission is willing to do some of it if we can pay at least part of the extra improvement. Now the question is how to finance the matter? Has the city the right to pay, out of the general funds, for any improvement that is outside of the city limits? I do not think it can be done. Has the city the right to assess the property which is within the city

limits for improvements that are outside of the city limits?

A Delegate:—I think that is a question for the city attorneys to decide.

Mr. Richmond (Seal Beach):—I am interested in 30 acres of property just west of Whittier on the state highway. They are putting in some highway pavement there that is very expensive pavement. The state is paying one-half of the cost of this pavement. Part of this highway is inside the city of Whittier and part is outside, just west of Whittier. And as I say, the state is paying one-half and the county is paying one-half of the remainder, or one quarter, out of its gasoline tax. And an assessment district was formed of the property owners, for some little distance on both sides of the boulevard, which district pays the remaining quarter. This quarter is paid by the forming of an assessment district.

Mr. C. H. Traber:—I think there are several features of this subject that have not been touched upon at all. The rule that is applied where the city and county are practically one, such as is the case in San Francisco, would be absolutely inapplicable in a town like Delano. In our town, the Board of Trustees has taken this matter up many times and argued it over, and finally we have come to the conclusion that the best thing we can do is to let it alone, that if this money is spent in maintaining rural roads surrounding our community, our city is benefited far more than if we got a small portion and paved a few of our city streets. Our main arteries are paved. In our locality we cannot complain at all of the treatment received from our Board of Supervisors, and I think that any county Board of Supervisors, if the particular municipality will approach them in the right way, that that municipality will get its just dues. Now, for instance, take our little town of 3,500 inhabitants. If we were allotted the entire county share of the gasoline tax on the machines belonging to our citizens, it would be unjust to the country around us. I think we should get legislation that is just to the counties and to the municipalities as well. And if the county Board of Supervisors will take that money and apportion it justly throughout the county, and build our laterals and highways and keep them in good shape, our city of Reedley will benefit far more than if we would take all that money and put it into our city streets. The automobile registration in a little municipality, I do not believe, is any indication of the pro rata share that it should receive of the tax, for the simple reason that the majority of the machines that are registered in a town are worn out on the surrounding country roads. I have thought that we were getting a just deal. And I think it would be wiser if the small municipalities would forget the little amount that they would receive from this fund and consider the amount of good it is going to do when this money is expended on the surrounding county roads. I personally do not care how many men come in from the country and use our highways and tear them up a little. Every man that comes in is going to leave a dollar or two or three dollars in that town. That is what we are there for. The man who said that if you took the rural country away from the city of Los Angeles, it would begin to decline at once spoke the truth. The man in a municipality does not produce a single thing, and without the surrounding country he would be lost. And we have got to consider the outsiders in the conduct of our city. Of course we want the money, we need the money, and we have got to have it. We are living in the city because we choose to live there. But if we want our streets paved, let us pave them. I think the legislative committee should take this into consideration when it goes before the Assembly and the Senate.

Mr. Sinsheimer (San Luis Obispo):—The trustees in San Luis Obispo have discussed this question along the same lines as the gentleman who just spoke. We feel that the entire gasoline tax should be spent on the county road. We feel able to take care of our city street paving necessities as the necessities arise. We look at it in this manner: that that which builds up our communities are the producers in contradistinction to the predatory element. The city contains the predatory element. Now, I do not mean to say that the residents of the city are entirely a predatory element, but if we can draw any great distinction along those lines, that distinction must be drawn between the city and the country. And that which builds up your city is certainly the surrounding country. And we are fully of the opinion that the law should be permitted to remain as it is, that the moneys derived should be devoted wholly to the improvement of the county roads, and the city to take care of its own streets. We have a very strik-

ing example of that in our neighborhood at the present time. A little community, consisting of a comparatively small number of people, located north of our city, tiring of the dilatory tactics of the highway commission, a few days ago voted to bond themselves for something like $300,000, in order to complete the highway from a point something like 15 miles north of the city of San Luis Obispo to a point some 40 miles north. They have asked nothing of anybody. They have shouldered the entire burden. They propose to build the road. And they say to us, and to everyone, "You are welcome, come as often as you please, we are very happy to have you come." And it seems to me that spirit is the proper spirit, the spirit of reciprocity, and the spirit animating us to take care of our own needs.

Mr. Kiernan:—I take exception to the remarks about the city being entirely dependent upon the country. Some of these country fellows would be in pretty hard luck if they did not get some help from the city. For an example, about all the asparagus eaten in the world is raised in the delta country near Sacramento. If it was not for the mammoth canneries up there taking care of that stuff, some of those farmers that are holding people up for $1,500 an acre, when they sell their farms, would not be riding around in a Rolls Royce as they are today.

Mr. Clark:—I think this matter ought to be thoroughly thrashed out here. I think the fact that as big a city as Los Angeles, with a group of intelligent men at the head of their government, is disposed to ask for a portion of the gasoline tax to help them pave their main arteries, certainly should be an example to us, a proof of the fact that it is no more than fair that every city in the State of California should have a little of that money to help them pave their streets. And I think that we ought to get back of this thing, and when this discussion is over I believe I would ask that this convention endorse some sort of legislation of this type. Now, I am not asking that the division be made in the same way that it is made to the counties, in proportion to the number of automobiles registered in the city, but I say that, inasmuch as the big cities have realized that it is right and proper to go before the Supervisors and ask for some of this money, it proves that we are entitled to it. Of course now it all depends upon whether or not the Supervisors wish to give it to us. If it is right for us to have it, then let us have some legislation that requires that they give us a little of that money, so that it will not be simply a question of whether they wish to do it or not.

Mr. Backus:—The country, to a certain extent, helps pay the gasoline tax. I just want to draw your attention to another thought that I got from a gentleman from Siskiyou County. He said that in that county they have very few roads. The Supervisors receive about $1,500 from the gasoline fund, and it is all frittered away in patching up roads here and there. Now, the State of California is a unit, and it seems to me we ought to look at this thing in a broad gauge light. Of course we people from the city feel that our city should get everything that is coming to them, but, at the same time, there is another way to look at this thing, and I think we ought to look at it in the light of the best good for the State of California. I feel that Los Angeles, for instance, ought to be big enough to go beyond their county line and distribute some of that money.

Mr. Wheeler:—We are distributing two-thirds of it. But that is not the point. We are satisfied, in the city of Los Angeles, with the action of our Supervisors, but this is the point: we are not going to play the dog in the manger. We are here as members of this League to help every other municipality in the state get the same things that we have got for ourselves.

Mr. Backus:—The city of Los Angeles can afford to distribute some of that money. Probably in Kern County or Tulare County, if it was distributed among every little town in Tulare County, say, it would not amount to anything, and the town of Delano and other places would get such a small proportion that it would not make any appreciable difference.

Mr. Park:—The Supervisors take just as good care of us in the eastern end of Los Angeles County as they do in the city of Los Angeles. I think that the trouble is that the distribution of the gasoline tax to the counties is not the right system. We cannot get an equal distribution among the cities. I have been down here in Long Beach for the past three days. And I have driven my car more miles since I have been in the city of Long Beach than I will drive it in my home city, Pomona, in 30 days. Coming down here to this convention, half

of my mileage was in Orange County and half in Los Angeles County. Now, if we could get the state to distribute that gasoline tax in a little different shape then some of these counties that do not have as many autos would have a larger revenue perhaps from that source. Los Angeles County is the second richest county in the country. It does not need the money that they get from the gasoline tax, as far as the county is concerned. It may help Los Angeles. Of course, they need all the money they can get. They are drawing people into this section of the country, and everybody that comes out here does not like Los Angeles, some come to Pomona, and Riverside and San Bernardino. We want our people to go to Los Angeles, and then, when they look around in the stores and find they can buy cheaper at home, they do their buying at home. The country people are more dependent upon the merchants in the city than the merchants are on the producers. I can raise chickens and I can raise pigs, and I can raise vegetables and fruit. And what more do I want, as far as food is concerned? I can get a goat and have my own milk. But if I want a suit of clothes, I have to go to a merchant for it. If my pump breaks down I have to go to the city and get the proper machinery. The merchant in the city has to take care of the people in the surrounding country, and the local merchant pays three times the taxes that anybody else does. So I think that the delegates here ought to take into consid eration, on this gas tax question, that it should be for the general benefit of the state and not for the individual counties. What put Los Angeles on the map? It was the Chamber of Commerce of Los Angeles, composed of business men. They spent their money freely. Who put over the Santa Barbara relief fund? They apportioned 60 percent of that fund among the business men. They have got to get it back, and they have got to have good roads to bring in the country people. I think the solution of this thing is to have an apportionment throughout the state and eliminate the counties from getting a large portion of the tax.

Mr. Sinsheimer:—The rest of us that are quite a distance from Los Angeles have an idea that Los Angeles is a bit selfish in what she does, and, while we keep a close eye on her, we usually try to work things out for ourselves. I would like to ask this question: Does the city of Los Angeles, or does any city in the State of California, apportion the taxes which it raises to the particular locality where the tax is paid? It absolutely does not. It regards itself as a political entity, and the entire city as a unit. You do not apportion, for instance, the money that is raised from the taxes on property along Broadway in Los Angeles to the improvement of Broadway. You apportion it to the entire city of Los Angeles. And as the gentleman said here a moment ago, the State of California is a political entity, and the money that it receives from every source should go all over the State of California to those places where it is needed, not particularly to the place where it is raised because if it did, one place would grow and prosper and the other place would not. But California is one state, it is one political unit, precisely as the city itself is a political unit, and there is not a council or there is not a governing body of any city in the State of California that would, for one moment, dare to spend the money that was raised in one particular place upon that particular place. And in my opinion that principle extends throughout the whole state, to the municipality, to the county and to the state. Now, as far as producers and the predatory interest is concerned, there are producers within the cities unquestionably. Any man that works, and any man that does his duty, whether he be a merchant or otherwise or managing a public utility, is a producer to the extent that a legitimate profit only is made. But when he goes beyond that he becomes, not a producer, but he becomes a member of the predatory interest. And the remark that I made a moment ago was merely to show that, if you can make any one particular dividing line, in so far as the producer and the predatory interests are concerned, irrespective of what the gentleman may have said a moment ago, the fact remains that the producing element is largely in the country section and the predatory element in the city, providing we could draw any one particular line.

The Chairman:—It seems to the Chair that we might hear some discussion as to whether all the money that the state gets should not remain with the state and be disposed of by it. It is a state tax. Should not all of the money be spent by the state? Many believe that all of the tax money that is derived under the state tax should be spent by the state and used according to the state's idea of how that

money should be spent. Mr. Kelso of the automobile club of Southern California is here. We would like to hear from you, Mr. Kelso.

Mr. Kelso:—I am a little bit disconcerted to think that anybody recognized me, or that you called upon me to speak on this subject, not that we are disposed at all to dodge any feature of the discussion, but another of our officials was expected to come down here and discuss this matter before you, but he was called east on business and could not be here, so I came down, without any instructions or any preparation, and not expecting to appear before you at all, but simply to get some idea of how you gentlemen felt about the subject. Now, of course, there are those different subdivisions of this question. First, shall all the money go to the state as your chairman states; second, shall the money be divided, as it has been heretofore, to the counties in proportion to the registration, or shall some of the money go to the cities? Now, as your chairman said, there are a good many people who are strongly of the opinion that all of the money should go to the state because it is a state tax, and the state is interested all over the state and not in any one particular locality. There are some very persuasive arguments in favor of that. I had the opportunity, just the other day in San Diego, to discuss the efforts of the Automobile Club of Southern California and the California Club also, to bring into the State of California transcontinental traffic. And I told the people in San Diego that they were interested, not only in the Bankhead highway and in the old Spanish trails, but they were interested in the northwest trails, and they were interested in the Lincoln Highway and in the other transcontinental roads, because every person, when they come into the state of California, does not want to stop in any one place particularly, they want to go all over the state, and certainly over all that portion of the state from San Francisco down to Mexico, and if they are real lovers of nature, they will go through that portion of the state from San Francisco north. So there are some potent arguments for giving all of this money to the state and letting the State Highway Commission expend it on those through roads which will bring the people into the state, and then let the communities take care of the people when they come into those particular communities. There is this feature of it: many of our counties have long open stretches where it would be a hardship for the people, in those particular districts, to bear the costs of the road. And that is why the present system was hit upon. Two or three of the larger cities feel that they ought to have more of the money to pave the roads within the cities, not the connecting links, but those roads, such as Mr. Wheeler referred to, where there is a good deal of city traffic, and where a heavier pavement is needed to accommodate that traffic, and where it does seem a hardship to require people owning property along that street to bear all of the cost. I am not in a position to say just what the Automobile Club of Southern California's policy will be at the next session of the Legislature. I think you gentlemen are convinced of the fact that the club wants to make such a proposition as is really fair, not to Los Angeles, not to Long Beach, not to San Jose or some particular locality, but to the entire state. I want to say this, on behalf of the Automobile Club, that it feels under obligation to a great many of the cities for the stand that the cities took with reference to the gasoline tax, to the increase in the gasoline tax. The cities came out very unselfishly. They did not ask that they should have their division in order to support or to oppose the particular increase. They were very unselfish about it and we appreciate what was done along that line. I cannot give you anything very definite about our attitude toward this subject. I think we are inclined to feel that we are more interested in the streets that are out of the city. Those of us who live in the cities ought to be able to take care of our own local problems. Yet the man from the city wants to find a good road wherever he goes. He does not want each locality to pave its roads in the way in which it thinks its own local needs alone require.

Mr. Evans (Riverside):—I do not think it would be wise to turn the money all over to the state and to put the expenditure of that money into the hands of the Highway Commission. Now our county has always had great sympathy for the work of the Automobile Club, but we are like many of the other sections of the state where there are a few cities, with small area, and large county area outside of those cities. The State Highway Commission takes a different view of where the roads ought to be put than do the county authorities. The development of

the counties would be enhanced by taking the county view rather than the view of the Highway Commission because the Commission builds a road for the shortest distance, at the least money, whereas the development of the county might be enhanced by building different types of roads and going longer distances. During the last Legislature we were importuned to say that we were in favor of all the money going to the cities. I do not know what the majority of the people in our city thought about it, but I did not feel that way, and I believe that the cities have an obligation to the country districts, and until the country roads are built up and improved, the roads that lead into the cities, I believe that it is better for the roads in the country to be improved, just as I believe that it would be better if the next hundred thousand people that come to Southern California never saw the inside of a city, but went out and settled in the country rather than to go into the cities. I had a little house in Los Angeles and it took me over six months to get a telephone into that house, after working all the friends whom I knew. I am rather inclined to think that only a small portion of the tax should go to the cities, provided some arrangement is made with the Supervisors for more cooperation in paving the many highways that lead through the cities. But, in a broad way, I am inclined to think that it is better to leave the matter alone until we are a little bit further advanced in knowing what we can do in building up our country roads and helping the very small towns and cities, which are practically part of the country, to build their main highways and build up the country roads, and leave the money as it is. But I would want to think a long time before I would turn the tax money over to the state.

Mr. Clark:—I would like to voice a little opposition to the argument in favor of turning all this fund over to the state for this reason: that I figure that any commission is made up of human beings, and there is just a little bit of danger of any set of men yielding to certain influences. The question is whether that money would not be expended, if it were all left in the hands of the state, too much in the localities where the greatest influence could be brought to bear, and it seems to me it is a more equitable proposition to give it to the counties and leave it up to the Boards of Supervisors to expend a portion of that money. The state, under the present law, gets half of that money any way, and that is certainly plenty for the Highway Commission to spend, and leave the rest of it for the Boards of Supervisors. And then, possibly, we might go further and ask that there be some legislation enacted requiring that a certain percentage of that money go to the cities. Take as an example the highway that runs say from the northern part of Santa Clara County up through San Mateo County to San Francisco. That highway goes through a great many cities, and yet practically all the traffic that goes into San Francisco goes along that highway and through those cities. About every 10 to 20 miles the highway runs through one of these cities with five or ten or twenty thousand inhabitants, and all of the traffic goes through those cities, but most of the benefit is going to San Francisco, say, many miles away from the cities referred to. That is a point that might be discussed, whether, on trunk lines, some aid should not be given to the cities along the route.

Mr. Barzellotti:—It seems to me that these questions were discussed last year, and we came to the conclusion that the state should contribute to the maintenance of those trunk lines going through those cities. In other words, it was the opinion of the delegates that it was not right that a state highway should cease to be a state highway at the border of an incorporated town and become one again at the other end of that town.

Mr. Locke:—There was a bill introduced at the request of the city of Fresno. The particular circumstances in relation to the matter, so far as I recollect them, were these: that Fresno had annexed some territory in which there was a part of the state highway, or a continuation of the state highway, and the State Highway Commission claimed jurisdiction over the highway, to the etxent of establishing the grade, and the city of Fresno disputed the right of the Highway Commission, basing that objection on the ground that the grades which the Highway Commission provides would not meet the grades of the municipality, and they would not carry off the storm waters. So a bill was introduced into the Legislature, and, before introduction, was submitted to the city officials of Fresno and approved by them, which provides that, in such case, the municipal authorities shall have jurisdiction over that portion of the highway, in so far as it ap-

plies to the establishment of grades.

Mr. Backus:—The State Highway Commission agreed on that and the attorney for the State Highway Commission agreed and endorsed that bill.

HIGHWAY LOCATION IN THE MIDDLE WEST

By Ralph R. Benedict, Assistant Chief Highway Engineer of Illinois, Springfield, Ill.

(Editor's Note: Following is Mr. Benedict's discussion of the paper read before the recent annual meeting of the American Road Builders' Association by Col. W. W. Crosby, Location Engineer of the Pennsylvania Department of Highways. As is well known highway location in the Middle West is influenced to some extent by old roads on the section lines. We have a checker board system of roads with a multiplicity of right angle turns at section corners.)

Educating the Public

The matter of highway location is one that has been led up to by the gradual education of the public due to the rapid increase of motor vehicles and mode of travel. Only ten short years ago if a highway engineer had suggested the relocation of a public highway across a man's field, cutting it in two parts, he would have been prosecuted as a dreamer and one who was bent on the destruction of private property rather than the building of roads. We have in Illinois a horrible example of such a location started approximately eight years ago—the matter of rounding corners with a 100 ft. radius was thought to be a foolish waste of valuable farm property and met with a great deal of opposition from the local people. The construction of this road has since served as a very valuable example, not only to highway engineers but to people of other localities who were interested in having roads located around their individual farm or home.

Manner of Locating Highways and Securing Right of Way

The early location and construction of highways is parallel to the early building of railroads in the United States. The railroads now are spending large sums of money to relocate in order to reduce grades and lengthen lines, so as to increase the speed of operation and reduce the cost of maintenance. This problem is an acute one for the highway departments of the older states where roads have been constructed for a number of years. The freedom of action in the location of state highways is greater I believe in the middle west and extreme western states than it is in some of the eastern states.

In the preparation of the first bond issue law for the construction of roads in Illinois, a very important step was made—in that the termini and intervening towns were described in the original bill and also were voted upon by the people of the state, thus making it impossible to juggle routes from one side of the state to the other with each change of political administration. Also, this law gives the highway authorities power to make such location between the towns mentioned in the bill as may become necessary in order to carry out the provisions of the act. The following is the exact wording of the law:

"That the general location of the routes upon and along which said proposed roads are to be constructed shall be substantially as described in this section, so as to connect with each other the different communities and the principal cities of the state; Provided, however, that said Department of Public Works and Buildings shall have the right to make such minor changes in the location of said routes as may become necessary in order to carry out the provisions of this Act; and provided, also, that said Department of Public Works and Buildings shall not improve hereunder any road or part thereof which lies within any incorporated city, town or village in which the building of state aid roads may be prohibited by the Act of this state entitled 'An act to revise the law in relation to roads and bridges,' approved June 27, 1913, and the amendments thereto."

At the beginning of the construction of a state program, the department attempted to acquire the right of way from the bond issue funds voted by the people, but it soon developed that some localities through which relocations were necessary were demanding excess prices for their land. The department therefore changed its policy and now requires that the local communities furnish the right of way needed. This policy has been very successful and in most cases has met with the hearty cooperation of township and county road officials. Our local authorities are able to procure such right of way at very much reduced prices.

It is the practice in Illinois to have a very complete reconnaissance survey

made before the definite location of the routes is decided. The very best engineers in the department are engaged in this survey work. A complete reconnaissance is made—measuring by speedometer or pacing relocations, the distance to travel, number of bridges to build, the number of railroad grade crossings, amount of grading necessary and all engineering features involved. A report is then made by the engineer on the various routes surveyed giving definite recommendations as to first, second and third choice. After this a public hearing is held and all of the people interested in the route are given an opportunity to be heard as regards the service the different locations may give to the local community. Upon the conclusion of the hearing, and taking the engineer's report as a basis, a definite location is selected by the director of the department and the Chief Highway Engineer. The location in connection with cities and villages is left to a detailed survey study. The engineer of design of the department then goes over the detailed survey report and makes such minor or major changes as may be necessary to secure the best possible alignment.

Relocation Makes Possible Saving in Cost and Travel

I have mentioned the outstanding location of one road in Illinois that is everything a state road should not be, with its multiplicity of right angle turns and adverse distance between two major termini. The major part of this adverse distance is the result of legislation; but some of it may be charged to location. As compared with this location, we have a highway between Springfield and Joliet in which relocation was made for 71.3 miles in a distance of 153 miles. A saving was made of 30.63 miles of travel; 62 right angle turns, and 22 grade crossings were eliminated. The saving on this stretch of road in dollars and cents to the motorists of Illinois, who are paying for the roads, based on a conservative traffic count of 1,000 vehicles a day at a cost of 10 cents per mile to operate is $3,063 per day—over one million dollars every year; or twenty millions of dollars over the life of the original bonds. There are a large number of instances similar to this throughout our state system, but the saving in mileage is not as great as in this particular case. A few of such locations follow:

Comparison of State Bond Issue Route 4 and Old Road (Burlington Trail) Between Springfield and Joliet

	Miles
1. Length of old road	183.60
Length of Route 4	152.97
Saving in length	30.63
2. Mileage of Route 4 on relocation	71.28
Mileage of Route 4 on existing roads	81.69
Total	152.97
3. Right angle turns in old road	59
Right angle turns in Route 4 (6 in towns)	7
Right angle turns eliminated	52
4. Railroad grade crossings on old road	30
Railroad grade crossings on Route 4 (2 by grade separations)	8
Railroad grade crossings eliminated	22

Note: Length of both roads is figured through all towns, from Springfield Postoffice to Joliet Postoffice. In computing right angle turns and grade crossings, no account is taken of those on either road inside of cities through which the state did not build.

Comparison of State Bond Issue Route 10 and Old Road (Burlington Trail) Between Jacksonville and Springfield

	Miles
1. Length of old road	39.41
Length of Route 10	36.00
Saving in length	3.41
2. Mileage of Route 10 on relocation	6.87
Mileage of Route 10 on existing roads	29.13
Total	36.00
3. Right angle turns in old road	20
Right angle turns in Route 10	9
Right angle turns eliminated	11
4. Railroad grade crossings on old road	7
Railroad grade crossings on Route 10	1
Railroad grade crossings eliminated	6

Note: Length of both roads is figured through all towns, from Jacksonville Postoffice to Springfield Postoffice. In computing right angle turns and grade crossings, no account is taken of those on either road inside of cities through which the state did not build.

Comparison of State Bond Issue Route 31 and Old Road Between Quincy and Ripley

	Miles
Length of Old Road	53.30

Length of Route 31	50.14
Saving in length	3.16
Mileage of Route 31 on relocation	17.78
Mileage of Route 31 on existing roads	32.36
Total	50.14
Right angle turns in old road	21
Right angle turns in Route 31	8
Right angle turns eliminated	13
Railroad grade crossings on old road	8
Railroad grade crossings on Route 31	3
Railroad grade crossings eliminated	5

Note: Length of both roads is figured through all towns from Quincy Postoffice to Ripley Postoffice. In computing right angle turns and grade crossings, no account is taken of those on either road inside of cities through which the state did not build.

Comparison of State Bond Issue Route 2 and Old Road Between Carbondale and Cairo

	Miles
1. Length of old road	59.92
Length of Route 2	55.36
Saving in length	4.56
2. Mileage of Route 2 on relocation	26.68
Mileage of R. 2 on existing roads	28.68
Total	55.36
3. Right angle turns in old road	14
Right angle turns in Route 2	0
Right angle turns eliminated	14
4. Railroad grade crossings on old road	6
Railroad grade crossings on R. 2	2
Railroad grade crossings eliminated	4

Note: Length of both roads is figured through all towns from Carbondale Postoffice to Cairo Postoffice. In computing right angle turns and grade crossings, no account is taken of those on either road inside of cities through which the state did not build.

The early method in vogue of locating a highway, namely to form a connecting link between two places with as little expense and labor as possible, has been fully outgrown in the minds of most highway engineers; and the matter of first cost is a secondary consideration to that of operation after the road is completed. It is surprising how little has been done by some of the states older in highway construction to eliminate features of distance and grades on those roads of early construction; but the question of salvage of the old road has been one difficult to overcome as an economic feature.

Even though half of the traffic on the highways of the United States is for pleasure purposes, as statistics compiled by the Bureau of Public Roads show, the matter of location is just as important to this class of traffic as it is to commercial traffic. Excepting in isolated cases where scenic attractions are paramount—such as the wonderful Columbia River highway, and the Rock River highway of Illinois—the uppermost thought in the mind of the locating engineer should be to obtain the shortest route with the easiest grades.

Highway Research

Although highway research has been confined chiefly to a study of surfacing, the results obtained have been productive in reducing the cost of such surfacing and thereby releasing more money for the location and construction of additional roads.

We are very apt to be critical of expenditures for highway research, but when results as outstanding as those of the Bates Road tests are reviewed, it behooves every highway engineer to foster and father as large a research program as his state may be able to carry on. The net saving to the State of Illinois as a direct result of the Bates Road tests is $3,600 per mile in standard road construction. This saving has amounted to approximately nine millions of dollars in roads actually built since this experiment was undertaken.

Safety Rather Than Speed Essential

It is possible for a highway engineer so to locate his roads as to contribute very largely to the safety of the traveling public in the elimination of serious curves, short sight distance and steep grades. I do not believe we should regard speed as one of prime importance in road location; but rather that we should regard safety as the outstanding feature or "fourth dimension." Following is one of the conclusions given in the report of the U. S. Bureau of Public Roads on a study of the California highway system:

"It is believed that on main roads more satisfactory results will follow a considerably bolder standard of location and under modern traffic conditions there is an increasing demand for improvement of alignment and fast travel between

cities. To this end design of highways must produce in general a road that can be traversed at the speed of 30 miles throughout without excessive operating cost due to change of speeds."

It is the tendency of the time to increase the limits of speed on rural highways. Some states are going even stronger than the above recommendation and are now advocating as high as 50 miles per hour on certain stretches.

Court Decisions in Favor of Highway Location

Recently, highway location has been drawn into the courts in the middle west. Some very important decisions have been handed down, upholding the highway engineers and officials; and against petty remonstrators. The latest decision of this nature is that given by the Supreme Court of the State of Missouri upholding the highway department in its location of an important cross state route so that it missed a certain village which would have taken through travel miles out of the way. At the present time Illinois has two cases awaiting the decision of the Supreme Court—one an appeal from a decision against the department, and one an appeal from a decision in favor of the department. Both of these cases are matters of relocation in connection with the State Highway System.

Conclusion

It has been contended by Mr. Crosby in his excellent paper that mass production tends to interfere with the proper study of highway problems. I would take very serious issue with Mr. Crosby on this point, as it has been our experience in Illinois that mass production is an incentive to better location, in that the locality benefited by the relocation or change in alignment will cooperate with the department and help to furnish the needed right of way with all possible dispatch. They realize that if this is not done, the roads in other localities will be built while they are awaiting the procuring of the necessary right of way. The question of the time needed for the study of location problems is only a matter of having sufficient engineers to make the preliminary surveys in advance of such a mass production program.

The mass production of Illinois has enabled it to break all highway construction records in the past three or four years.

PAYING FOR CAR TRACK PAVING

By J. W. Howard, C. E., E. M., Consulting Engineer, Roads, Streets, Pavements, No. 1 Broadway, New York, N. Y.

(Paper read before New Jersey State League of Municipalities on Jan. 22, 1926.)

Pavements within street railway tracks are properly at the expense of the railways and should not be made a public charge, as the railways are trying to accomplish by legislation in many states. Some of the reasons that to do so would be against public interests, unjust and illegal are herein submitted.

1. Due to the presence of a street railway in a street or road and its use by trolley cars, the initial cost of construction of pavement per square yard in track area is more than that of pavement outside of track area, and the repairs to pavement in and near track areas cost many times that elsewhere.

2. In repaving streets recently in many places in New Jersey and elsewhere, it was found necessary to isolate the track areas by using deep granite headers with their tops flush with the pavement outside and away from the outermost rails. This was done to conserve the pavements in the area on the sides of the streets, and has added many years to their lives. This isolation of tracks confines injuries due to the trolley cars to the track area pavement. It was all the more necessary because in many cases the track system is poorly built and insecure, often because weak and inferior types of railway construction or repairs, including worn stone blocks, were used by trolley companies in the track areas, or paving had been neglected for several years by the trolley companies.

3. The dual administrations by cities and trolley companies can never be in accord as regards proper construction and repairs of pavement within and near tracks. A city, county, or state should not permit a track area to be paved unless the track construction is solid and satisfactory and *in a condition acceptable to the authorities.*

4. No municipality can afford to lay and maintain pavements in track areas over insecurely constructed track systems.

5. In most cities, pavements are guaranteed by the contractor for a period of two to five years. No contractor or bonding company would give a guaranty to pavements in track areas.

6. Pavements between and adjacent to

poorly constructed or poorly maintained tracks, would be a very great extra expense to the public. To assess such cost or any part thereof, on the taxpayers, would be using the public money for the benefit of a private railway corporation, and would be taking taxpayers' money without due recompense. Hence it would be unconstitutional. It cannot be legally assessed either against the abutting property owners or the taxpayers at large. To do so would cause taxpayers' injunction suits and refusals to pay illegal assessments.

7. The repair and maintenance of pavements in good condition within and adjacent to track areas is much greater, as previously stated, than for corresponding types of pavement away from track areas or in streets having no tracks. This is due to various causes as noted below, arising from railways being there.

8. The poor types of construction of tracks and of track area paving often damages pavements beyond repair. The wooden ties are frequently not creosoted and consequently decay. The rail movements from the impacts of trolley wheels soon cause the rails to move vertically, cut into the wood ties and destroy the pavement between the rails and adjacent to them outside the track area.

9. Under even the best types of United States general street railway construction the vibration of rails causes the openings all along between the rails and pavements, which permit water to enter under pavements, to their injury, and in winter this water freezes and heaves the pavements, which damage increases progressively.

10. The heavy impact of all car wheels breaks up the pavement adjacent to rails and in many cases forces outward and upward the stone block and other pavements adjacent to the tracks. This damage is today far more severe than that caused by the foot of horses or mules when horsecars were used, horsecars having had only one-fifth the weight of an average trolley car.

11. The franchises of the Public Service and other trolley companies require the use of the best modern types of street rails, which are grooved, flat rails, and permit the vehicles to cross them in any direction without bumping and facilitate street drainage and street cleaning. Lately, an old fashioned type of rail with an L or step has been used, which leaves a depression on the inside of each rail. These rails impede direct or diagonal crossing by automobiles and cause extra impact and damage to pavements on both sides of all such rails, which also causes skidding of automobiles. Cities could never pay for paving where such rails are used, nor properly repair pavement near them.

12. The damage to pavements due to the presence of rails and use by trolley cars with their unavoidable vibrations and impacts, is far greater than that done by the light horsecars and horses' hoofs of long ago.

13. The presence of tracks was the principal cause of ruin of the wood block pavement on Board street, Newark, New Jersey, so that it became irreparable after ten years 'service. Its cost was about $400,000, and it had to be entirely replaced in 1925, over the whole street, at about the same expense. West Park Street, Newark, New Jersey, has no car tracks and wood block pavement has been there twenty years and is still good. Washington Street, East Orange, laid at about the same time as Broad Street, Newark, is still good, having no car tracks. The same is true of Mechanic Street, Newark, New Jersey. There are many other streets where the track areas of pavements have been destroyed, while the same kind of pavement of stone block, asphalt, etc., where no car tracks exist, are still in good condition.

14. The operation of trolley cars in streets causes dangers and delays other vehicles, so that track areas are relatively little used by the public.

15. Some track areas are paved by the trolley companies with old, second-hand stone blocks which are bumpy, unpleasant and dangerous to motor and horse traffic, and discourage or prevent public traffic from using the track areas. This is caused by roughness and excessive height of the paving of stones, and causes skidding. Under the best conditions of tracks and pavements between them, the public can make little use of track areas due to the necessity of constantly and legally giving right-of-way to trolley cars, and in certain cases passing eight feet to the right, thus reducing effective street area and causing additional danger to traffic—all due to trolley cars.

16. An ever-increasing percentage of the people (now about 30 per cent) do not use trolley cars. These non-users should not be taxed for any street railway expense, of paving or otherwise, for the benefit of users of trolleys.

17. Several kinds of very economical

pavements are successful on areas of streets away from car track areas, whereas different and more expensive pavements must be used in track areas. Therefore, the extra expensive pavements in track areas should not be laid at the expense of taxpayers.

18. The presence of street cars on the streets causes danger to children and people, noise and nuisance to residents, and is a detriment in other ways, frequently depreciating the value of residence property on trolley streets. In almost every case where tracks are to be laid in a new street, the residents rise in protest. Yet the proposal is to levy the cost of trolley area pavement upon those same residents.

19. Many trolley companies have deferred paving or making proper repairs and maintenance to track areas in the past, resulting in dangerous and deplorable conditions. Regardless of future paving requirements, any legislation should not attempt to relieve them from past and existing obligations to pave at their own expense under their charter agreements and by law. Trolley companies should bring existing track pavements up to the full standards of construction and condition required by their franchises. To attempt by law, to do otherwise would be retroactive legislation which would be unconstitutional.

20. It is not equitable or just that the taxpayers, either by assessment for pavements on streets or by general taxation in any way, should pay for first construction or repairs, or maintenance of pavements within street areas occupied by street car rails or railway ties or support under the rails.

STONE ROAD CONSTRUCTION

By E. D. Nesbitt, Jasper County Engineer, Rensselaer, Ind.

(Paper presented at 12th Annual Road School, Purdue University, Lafayette, Ind. Jan. 18, 22, 1926.)

During more than ten years of being in charge of stone road construction in Jasper County, Indiana, we have made some rather radical changes in our standard specifications, especially with regard to the size of stone and the manner of placing.

In making such changes we have kept in mind, First, the original cost to the tax payer; second, the cost of maintenance, and third, the service to be rendered, that is, the amount and weight of traffic.

Jasper County has been very fortunate in having their heavy duty roads taken over by the State, thus leaving the 460 odd miles of County roads subject to moderate to light traffic.

Before the work of construction is begun the centerline of the road is marked by stakes set along the margin of the road at 500 foot intervals and plainly marked with the number of feet to the center of the road. These centerline stakes are set from corner stones or other controlling marks which must conform to the lines as determined at the time of the original survey and cross-sectioning. Station stakes are also set along the margin of the road showing the location of each station. Grade stakes are also set on both sides of the road at each station. The grade stakes are driven so the top of the stakes are flush with the finished grade in the fills and in the cuts they are left above grade and the cuts plainly marked thereon.

After the stakes are placed, the first part of the construction necessary is the clearing and grubbing. However, I will not go into detail on clearing and grubbing as it is pretty well understood what the requirements are to make way for a good roadbed. Then comes the work of building the grade, cutting the side ditches and placing all cross drain pipes and concrete headers.

In building the grade, proper allowance shall be made for any and all settling and shrinking. Care must be taken to have the finished grade conform closely to the lines and cross-sections shown on the profile.

It is extremely important so to construct the side ditches that they will drain the road wherever it is possible to obtain an outlet. Also tile drains are provided for on each side of the road wherever a sufficient outlet is obtainable.

We have found that the most successful method of eliminating so-called "quicksand pockets" is by the proper placing of drain tile.

All cross drain pipes are specified of corrugated metal and conforms to the state specifications on corrugated metal pipe.

Here is a paragraph taken from our standard specificiations on "Material."

Material

"The material for the improvement shall be of crushed limestone and of the best quality obtainable and in all cases the stone must be of hard and compact texture of uniform grain. The stone must be of cubical form, broken, crusher-run

stone and shall have a French coefficient of wear of not less than five (5) and to pass through a ring not greater than one inch in diameter. The stone is to be tough, strong, and uniform in color, no soft, spongy stone will be allowed on the improvement.

"Whenever any portion of the grade of the road, not less than five hundred (500) feet in length shall have been completed to the satisfaction of the engineer, he shall give permission to place macadam upon such portions of the grade as in his judgment seems best. There shall be spread a layer of crusher-run limestone of not less than ten (10) inches in depth and ten (10) feet in width requiring not less than thirty and eighty six hundredths (30.86) cubic yards of limestone per each one hundred (100) lineal feet.

"The finished surface of the macadam, ten feet in width shall have a crown of three inches and be of the form of a parabolic curve. All material shall receive a backing of earth along the outer edge to hold it in position.

"The grade boards shall be set on both side of the macadam in advance of the dumping and are not to be removed until backing and levelling up flush with the tip of the same is complete."

In the foregoing paragraphs there is nothing mentioned about rolling the subgrade or the stone.

Ten years ago we included extensive and rigid specifications concerning the rolling of subgrade, and stone, and a lot of money was spent for rolling. But close inspection has been kept upon these roads that were built of 2½ in. stone base and rolled, and the maintenance has been high compared with the road built with 1 inch crusher-run stone.

We have observed and decided without a doubt that placing the money we used for rolling into additional stone and drain tile that we are getting much more for every dollar spent.

To give you some idea of the cost per mile under the foregoing specifications, I have taken the contract price on the last ten roads built in Jasper County and the average contract price is $5,311.00 per mile.

THE MAINTENANCE OF GRAVEL STREETS AT MARTINSVILLE, IND.

By E. D. Canatsey, Morgan County, Surveyor, Martinsville, Ind.

(Paper presented at the 12th Annual Road School, Purdue University, Lafayette, Ind., Jan. 18-22, 1926.)

The maintenance of gravel streets embodies a number of elements not encountered in the regular maintenance routine on County and State gravel roads.

The greatest difference is due to the use of road oil on streets. Instead of a thin carpet of loose gravel to work with the ordinary maintenance tools, we have a smooth hard surface, and instead of the wash-board surface to contend with, in dry, hot weather, the oiled streets break in small round, basin-shaped holes, that quickly grow larger and more numerous; we call them pit holes. This evil of the oiled street is by far the most difficult problem to overcome.

But to begin at the beginning, I think we should start in mid-winter. This is the proper time to begin preparing the streets for oil. We will assume that the roadbed and curb ditches have been properly constructed and maintained. While the streets are frozen solid, is the best time to apply a very thin layer of good gravel. Apply it over the sections that show weakness of surface, that is where the pot holes form in great number. This gravel should have a minimum of sand, but should all pass a 1 in. screen, or better still the ¾ in. screen. By trial of different seasons of the year for adding new metal to the oiled surfaces, I believe best results are obtained by applying when the road is frozen. The metal added at this time seems to stick where applied, and as the frost leaves the roadbed the new gravel bonds and keys itself into the old surface. The use of the drag, during the freezing and thawing weather, over surfaces treated, will obliterate the pot-holes.

As the oiling season approaches we must begin the final prepartion for the application of the oil.

Usually in the latter part of May, after the heavy spring rains, we apply the oil, but the streets should be in first class condition before the oil is applied. A light scarifying is best at this time. Formerly in Martinsville this was done with a specially constructed street harrow. This tool will scarify an inch or two of the old oiled surface, then with a grader a uniform surface can be made.

The oil should not be applied when the ground is too cold or when there is much dust. The light scarifying allows the hot oil to penetrate deeper and faster than otherwise.

We apply the oil with a pressure tank

distributor which has an inside burner. The temperature of the oil, while being applied runs from 130 to 180 deg. F. Steam is applied to the tank car about six hours before the oil is pumped into the distributing tank.

We usually oil every other street, say east and west, then every other street north and south. About a week or ten days later the remaining streets are oiled. This allows traffic to avoid the freshly oiled streets to a certain extent.

An experiment was tried two years ago on four blocks where traffic was heaviest. Following the oil tank, torpedo sand (i.e. sand that passed the ¼ in. and was retained on an ⅛ in. screen) was spread on the hot oil, just enough to kill the flow and thicken the oil on the surface. This required about 10 cu. yds. per block—the street being 40 ft. wide. This showed good results, the oil was not tracked away much and a surface was obtained that was smooth and lasted well; this torpedo sand is obtained from a local gravel plant and is a bi-product made in getting out concrete material for the state. New gravel streets usually take oil nicely the second year and can be easily maintained. With the older streets it is a different proposition. In Martinsville the oil used always runs from 50 to 70 per cent asphalt and lasts on the surface from year to year.

With the hot, dry weather, and heavy traffic, the aforesaid pot-holes begin to show in all city gravel streets. It is useless to attempt to fill these holes with fresh gravel. This seems to accelerate the grinding out of the holes.

Light scarifying is necessary. The street harrow and horse-drawn grader is too slow and expensive. The power grader with scarifier attached is a very successful tool. The machine used in our city is the Weir, others no doubt will do the same work. The machine has a 10-ft. blade and the scarifier is just ahead of the blade. To do light scarifying leave all eight of the teeth in; if deep scarifying is required use only four teeth. The idea in scarifying the oiled street is to get enough of the oiled gravel to fill the holes. After the scarifying, the blade is set at a slight angle to cast the material from the center. You will be surprised at the amount of black material the blade will gather, after the light scarifying. This material will stay in the holes. The reason for setting the blade to cast outward is to flatten the crown. Most of our streets have too much crown.

The great advantage of the one-man power grader can easily be seen. When scarifying or grading he can stop at any time and back up as many times as necessary to fix a particularly bad spot in the street.

By careful handling, the streets can be lightly planed over with the blade and enough material carried along to fill all depressions; but, it is impossible to try to cut very much without the danger of rolling up the entire oiled mat and spoiling the surface of the street.

When a street becomes extremely rough, it is always best to scarify the oiled surface thoroughly, then level up with the blade. The surface in such cases should be scarified as deep as the bottom of the deepest holes. The 1,800 lb. dual wheels roll the surface down pretty well and the street soon looks as black as before.

When planing the streets lightly to keep small holes filled, I prefer working from the center toward the edges, then if any excess material is left, work this back to the quarters, this is the section that usually gets most of the wire and breaks first.

Sometimes we have sections of streets that need reforming entirely. In the case I have in mind, the street was arched up in the middle of the block, or at the alley, about 18 in. too high; we scarified the gravel about 6 in. deep, then with the blade this was graded to the curb in a narrow ridge. This operation was repeated over and over until all of the gravel was transferred to the curbs. Then the sub-grade was scarified and ridged with the blade in the center of the street until the proper grade for the sub-grade was reached. This loose material at the center was hauled away and the gravel was replaced with the power grader in even layers. When the job was completed the street was rolled down and smoothed by the big dual wheels of the grader. In this special case the gravel was removed from one block of street; about 60 cu. yds. of sub grade material was removed and the gravel replaced in 15 hours. This force employed was one man with power grader—two teams, and two extra men.

This piece of street was oiled about two weeks later, and the oil went in, in good shape; this street stayed in good shape throughout the summer.

One word in regard to oiling—as there are some who oppose street oiling. There are two points to be mentioned on this subject that prove the value of street oil-

ing, aside from the feature of preventing dust.

The first is the saving in the wear on the surface. Two years ago we left gaps about 6 ft. wide across the streets at sidewalk crossings, unoiled. This was to give pedestrians a place to cross without walking in the fresh oil. The unoiled strips in some cases were down as much as 4 in. lower than the oiled section adjoining. This gives some idea of the amount of road metal saved on our 22 miles of graveled streets in one year.

The other point is in the matter of water saved. Just before oiling, in late spring, water is used in great waste by people living in graveled streets, to keep down dust. The water superintendent's daily pumpage report shows a marked difference in water used before and after oiling.

Either of these two points show enough gained to prove oiling worth while.

Summing up the subject of maintaining oiled gravel streets we must bear in mind that in maintaining these streets we must not destroy the effects of the oiling, hence we must maintain with the oiled gravel which varies in thickness from 1½ in. to 4 ins.

Scarify lightly as often as necessary and plane the surface often with a heavy type power grader of long wheel base.

REPAIR METHODS FOR CONCRETE ROADS

By A. H. Hinkle, Superintendent of Maintenance, Indiana State Highway Commission, Indianapolis, Ind.

(Paper read before annual meeting of Mississippi Valley Highway Departments at Chicago, Jan. 15, 1926.)

Some persons maintain that the concrete pavement is so permanent that we need not worry much about methods of repair. One might think this could be true when he learns the concrete pavement around the court house in Bellefontaine, Ohio, was constructed in 1892, 1893 and 1894. Although this pavement is worn badly at some of the joints, much of it is good and still shows the imprints of the surface finish after having been used by traffic over 31 years. (A stretch 10 x 220 ft. on the west side of Main Street was built in 1892 and the other parts in 1893 and 1894.)

In view of the later experience with concrete roads it seems almost a miracle that such a good pavement of this type was built so many years ago. In this road there evidently was produced the high type of concrete that is being produced today. No doubt its preservation has been aided by a good foundation. Although this early constructed concrete pavement has weathered the heavy traffic well and much of the concrete constructed the last few years is perhaps of even better quality than this pavement, many of the early concrete roads were not properly constructed to carry the modern traffic and as a result they are requiring extensive repairs. Due to various causes the most extensive of which are defective foundations, overloading the pavement, and the usual defects of construction which are liable to creep in, this type of pavement will, like any other type, need repairs. Also, it must be ever kept in mind that any type of pavement will eventually wear out. Because of the above and the great mileage of concrete pavement now being built, it is important that we study the most economical methods of repairing it.

The defects which are found in a concrete road may be classified according to the nature of repairs required, as follows:

1. Ordinary cracks and joints.
2. Large cracks and joints, say wider than 1 in.
3. Small depressions or disintegrated places in the surface shallower than ¾ in.
4. Surface depressions deeper than ¾ in. but with good concrete remaining that will serve as a base for the patch.
5. Portions of the slab which are broken through and which should be replaced with a full thickness of new concrete.

The various methods of repairing these defects are described in what follows:

Ordinary Cracks and Joints

Ordinary cracks and joints should be filled with bituminous material, once a year being sufficient if on light traveled roads and two or more times a year if the traffic is heavy. In other words, the frequency of filling the cracks or joints should vary with the amount of traffic and hence the rate at which the filling is removed or the cracks develop.

Cleaning Joints or Cracks

The crack should be well cleaned for a depth of not less than 3 ins. of all dirt, dust or other foreign material. Under the heavy inflated tire traffic now going over most of our roads, the traffic itself largely does this cleaning due to the suction caused by the tire quickly rising from the surface. It is not deemed nec-

essary to remove the particles of aggregate from the crack if they are not mixed with soil or other foreign material. The necessary cleaning can usually be done with an ordinary house broom. Compressed air outfits mounted on a truck by means of which compressed air under 75 lbs. to 125 lbs. pressure is forced through a nozzle, are very effective and will readily clean the joints or cracks to their full depth. Such a pressure is very effective in removing all loose spalls. I am not convinced, however, that for ordinary purposes, it is economical to go to the additional expense of providing such an outfit; for, as stated above, the modern traffic does most of the necessary cleaning. When first filled, the crack is usually found open its full depth. For successive fillings the sweeping method apparently is satisfactory.

Grade of Bituminous Material

We have been using an emulsified asphalt meeting our AE-1 specification; or a tar meeting our TP-2 specification which is practically the same as the TP-2 specification of the Bureau of Public Roads. Emulsified asphalt is applied cold and this is an item of economy which is quite a saving in cost, particularly where only small quantities of the material are required. The tar TP-2 must be heated to a temperature of about 225 degs. F. While the cost is less to apply the emulsified asphalt, its first cost is considerably greater. The relative costs of these materials delivered in our state in barrels in less than car load lots, this past year, has been 25½ cts. per gallon for emulsified asphalt and 19½ cts. per gallon for the tar TP-2. The emulsified asphalt freezes and is ruined in cold weather and hence it can not be satisfactorily used during the late fall, winter and early spring season. We have followed the policy of using the tar where large quantities of material were required. The cost of heating in large quantities is not so great as where a small quantity is required. Also, as it is usually desirable to do some work late in the season and early spring or even occasionally during the winter, hot tar is used at these seasons of the year. The emulsified asphalt has an advantage in that it can be used when the surface is damp or even wet while for best results the tar should be used only on a dry surface. It will thus be seen that each of these two materials has its advantages under certain conditions of weather, quantity to be used, etc.

Applying the Tar or Asphalt to the Crack

The emulsified asphalt is applied cold. It can be poured into the crack with a small pouring can of not to exceed 2 gals. capacity. An ordinary water sprinkling can with the end of the spout broken off serves the purpose very well. Some of our men have used a coffee pot shaped vessel holding about 1½ gals. and insist that it is the most desirable pouring can that can be secured. It is desirable not to use too large a pouring can as this will make it more difficult to apply just the right quantity of the bituminous material. For pouring the hot tar, it is necessary to have a well made pouring can so that it will not be injured by the heat melting the solder. However, owing to the fact that this grade of tar is not required to be heated to such a high temperature as the heavier grades of tar and asphalt, frequently the better grade of ordinary water sprinkling can, can be used satisfactorily for some time before it is injured from the heat. If a heavy metal can is used such as to guarantee against injury from heat, it makes it more difficult for the pourer to put on just the right quantity of bituminous material and furthermore unnecessarily tires the workman because of the heavier load which he is all the time carrying. After the hot tar or asphalt is poured and before the covering is applied, the bituminous material may be uniformly distributed in the crack by drawing over it a small "V" shaped tool. This aids in putting the surplus material which is left at some places, into the places where the material has run down or there is a shortage because insufficient material was applied. The first time the crack is filled it will usually be necessary immediately to go over the crack a second time and refill those places where the bituminous material has all gone down into the crack. However, on refilling the cracks this second application will ordinarily not be required.

Perhaps no one thing is more important in this work than to guard against using an excess of the tar or asphalt. There should never be more of the bituminous material applied to the crack than will just fill the crack and extend over the edge of the concrete about ½ in. after traffic has 'ironed it out." Experience and observation will soon teach one how much material to apply to secure these results. The bituminous material will rise up in the crack to some extent after the covering material is put on and this

should be taken into account in pouring the proper amount of material. If an excess of the bituminous material is applied, successive applications will build up a ridge across the pavement which is quite as objectionable to traffic as the depression due to the spalling of the edges if the crack is left unfilled.

Covering Material

Any fine grade of aggregate varying in size from the lower limit of a good concrete sand up to a grade of stone, slag or gravel which will go through a ½ in. circular opening may be used for covering. Even a bank sand that contains considerable more soil than permitted in good concrete sand has been used with very satisfactory results on the emulsified asphalt. With the tar, it is desirable to use a cleaner grade of material. While quite a range of size and quality of covering material seems to give very good results, it is desirable to secure a material ranging in size from ⅜ in. down to coarse sand. The covering material can be spread on the newly poured tar or asphalt from a bucket by hand or from a wheelbarrow with a shovel. As much covering as will readily be absorbed by the newly applied tar or asphalt should be used. Although it may be a waste of material to put on an excess of the covering, the excess ordinarily will do no serious damage. It is desirable to guard against putting on too coarse a covering for small cracks and joints as this will add to building up a ridge.

Cracks and Joints Wider Than 1 In.

Where the cracks and joints are wider than 1 in. it is best to fill the cracks with bituminous mixture. For this purpose a graded aggregate of stone or slag ranging in size from ¾ in. to ⅛ in. should be used. Either the emulsified asphalt mentioned above, a cut back asphalt, or a cold mix tar may be used as the bituminous material to mix with the aggregate. Any one of the standard hot mix bituminous concretes can be used for this purpose. Usually, however, due to the small quantity of the mixture required it will be more economical to use one of the cold mix products. After the mixture is placed in the crack, a small amount of the same grade of hot tar or emulsified asphalt used in filling ordinary cracks should be applied so as to paint the edges of the crack. This will form a bond of the mix to the concrete and tightly seal up the crack.

We have attempted to fill large cracks with "Quick Hardening" concrete meeting the specifications for this kind of concrete hereinafter described. It is necessary to reduce the size of the coarse aggregate (or omit it entirely) so that the mixture will go into the crack. Although I would not condemn this method of filling large cracks, I will say that so far we have not found it highly successful. The crack is usually not a stable thing. The same force that originally formed it is still working and causes it to vary. These forces break and crush up to some extent the thin sliver of new concrete. When a crack is filled in this way there usually results in a short while two cracks, one on either side of the filler. These, of course, can be filled and maintained as any other crack with bituminous material. We will carry on further experiments with this kind of work, hoping yet to evolve a satisfactory method of filling large cracks with concrete.

Small Depressions in the Surface and Disintegrated Places Shallower Than ¾ In.

Shallow depressions, or slightly disintegrated places in the surface which are, say shallower than ¾ in., may be filled by painting the depressed or disintegrated surface with either the emulsified asphalt or hot tar described above and coating it with fine aggregate ranging in size from ¾ to ¼ in. This produces what is ordinarily known as a "paint patch." Successive applications of the bituminous material and covering may be used to secure the desired thickness. Care must be taken not to use an excess of the bitumen as this may result in waves or rolls forming under traffic. If it is difficult to build up the desired thickness by this process, then the method next described should be used.

Surface Depressions Deeper Than ¾ In. but With Good Concrete Remaining That Will Serve as a Base for the Patch

Such depressions should be filled with a bituminous concrete mixture made of a graded aggregate ranging in size from ⅛ up to 1¼ in. or not to exceed 2/3 the thickness of the hole to be filled. Although the mix made from ¾ to ⅛ in. material will ordinarily be satisfactory, it is always desirable to use some coarser aggregate if the hole to be filled is of considerable size. It is very imperative that a graded aggregate ranging from the smallest size up be used in any mix for if the finer size is omitted, the mixture will be so open that it is liable to ravel and disintegrate under traffic. Emulsified

asphalt AE-1 described above is satisfactory for use in making this mixture. A cut back tar (cold mix tar) may be also used. It will require about 17 to 20 gals. of the bituminous material to 1 cu. yd. of mixture. This cold mix bituminous concrete should be leveled off and tamped into the depression with a heavy tamping iron taking all the precautions in securing a level surface that is ordinarily taken in spreading bituminous concrete either of the hot or cold mix variety. Where the depression is less than 1½ in. in depth, the old concrete surface should be painted with emulsified asphalt or a hot tar before the bituminous concrete is placed in the depression. It is not deemed necessary to paint the old surface where the depth to be filled is greater than this. If the surface of the mixture after it is spread, leveled and tamped has the appearance of being open due to insufficient fine aggregate in same, it should be given a seal coat of the tar or asphalt and covered with fine aggregate or coarse sand.

Portions of Slab Which Are Broken Through and Which Should Be Replaced With a Full Thickness of New Concrete

Where the concrete slab is so broken that it will not be economical to patch it with bituminous material as described above, the old concrete should be removed and replaced with new concrete as described in the following paragraphs:

Removing the Old Concrete

The old concrete can be removed by hand with picks, chisels and crow-bars. If any quantity of work is required it will be far more economical to use a paving breaker operated by a small portable air compressor in doing this work.

All the broken and disintegrated concrete should be removed and the old slab cut back until solid, rigid, concrete is reached which has on top a smooth and uniform surface. The top edge of the old concrete should be trimmed by hand (with the use of hammer and chisel) to a uniform and vertical edge for a depth of about 1 in. below the top surface. The remainder of the vertical edge of the concrete should be left as rough as possible.

Preparing the Sub-Grade

The sub-grade should usually be excavated to a greater depth than the original slab. At its junction with the old pavement the thickness of the new slab should be increased. The exact depth of the new concrete should depend upon the nature of the subsoil. The old concrete slab has failed for a reason. Quite frequently this reason will be found to be the soft clay sub-soil. Therefore, the thinnest depth of the new slab should usually be 2 to 4 ins. deeper than the old pavement. In spongy, clay soil, not only should the depth of the new slab be increased but it is also an added factor of safety to tamp into the sub-grade a 3 to 4 in. layer of cinders, gravel, or broken stone with an outlet to the side ditch, as shown in Section A-A in the design, herewith. This will reduce capillary action in the clay and also help drain the surrounding sub-grade. The new concrete should extend back under the edge of the old slab several inches. (See design.) The base of the projected edge of the old concrete should be thoroughly brushed to remove any spalled concrete or dirt.

Composition and Proportion of Concrete

The concrete used in replacing the old concrete may be of a standard mix used in the building of modern concrete pavements. If such a mix is used, it would require closing the road from 25 to 28 days to protect it against traffic until it hardens. For this reason it is usually desirable to use a "quick hardening" concrete in order that the pavement may be opened soon after the patch is laid. Frequently only small patches will be required and the added cost of the "quick hardening" concrete will not be a serious matter. This quick hardening concrete may be made by the use of aluminite cement in the same proportion as ordinary concrete is made. Concrete made of aluminite cement hardens sufficiently in 24 hours to permit it to be opened to traffic. Quick hardening concrete that may be opened to traffic in two days after laid may be made of ordinary Portland cement as described under the next heading.

Quick Hardening Concrete Made of Ordinary Portland Cement

Quick hardening concrete made of ordinary Portland cement depends for its early strength upon: (a) Richness of the mix, (b) freedom from excess water, (c) use of $CaCl_2$, (d) comparatively high atmospheric temperature when curing, (e) time of mixing, (f) use of coarse sand and a properly graded aggregate. By taking advantage of all of the above five factors which affect the time of hardening, in one mixture, it is possible to make a concrete patch of ordinary Port-

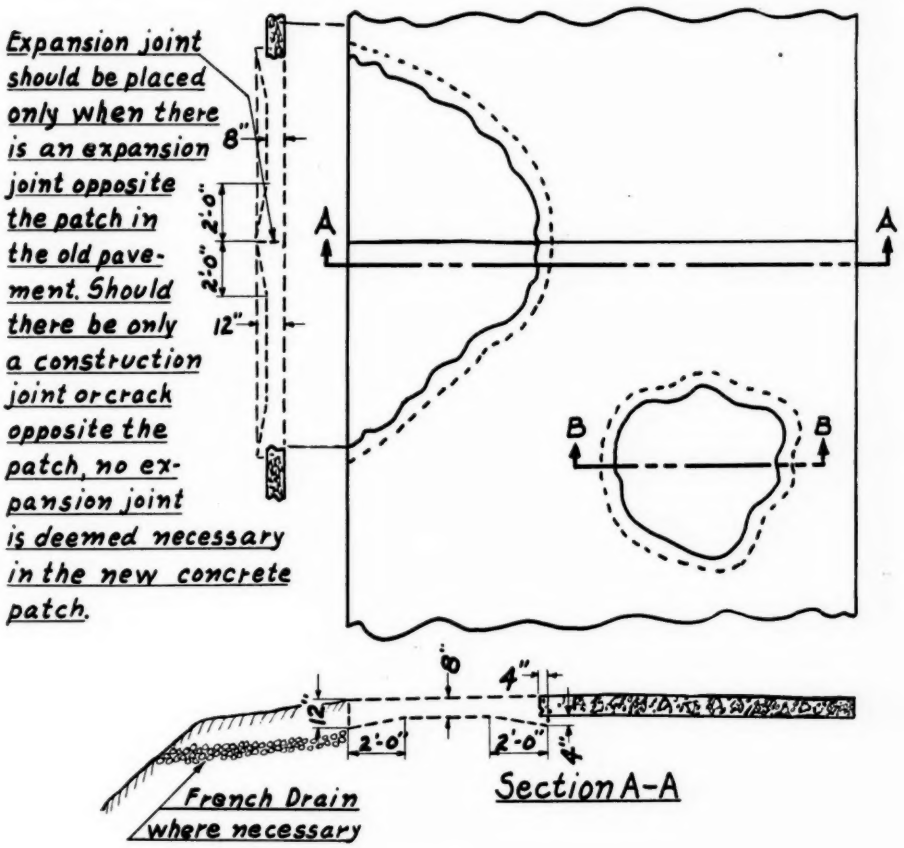
land cement which can be opened to traffic two days after it is laid.

Richness of Mix

The proportion of cement that should be used to secure a patch which can be opened to traffic after any number of days is shown in Table 1, page 7. It will be observed from this table that to secure a patch which can be opened to traffic after two days' time, the proportion should be, 1 bag of cement, 0.5 cu. ft. sand, 1.9 cu. ft. coarse aggregate, 2 lbs. $CaCl_2$, and only enough water to produce a slump in the concrete of about 1 in. Other proportions which should be used in making a patch that can be opened to traffic after any number of days are found in the table. This table is based, in a general way, on data furnished by Mr. Duff Abrams of Lewis Institute, Chicago, Ill. The compressive strength of the mix when it is to be opened to traffic is about 3,000 lbs. per sq. in. with an atmospheric temperature of 70 degs. F.

Freedom from Excess Water

In order to secure the maximum strength of concrete, it is necessary to use a dry mix. (See Bulletin 1. Structural Material Research Laboratory, Lewis Institute, Chicago, for the strength of concrete with various percentages of water.) While a dryer concrete than a 1 in. slump will give greater strength it is impractical to make a patch from too dry a mix



DESIGN OF SECTION OF PATCH.

and hence a 1 in. slump is recommended as being the driest mix that it is practical to use.

Use of Calcium Chloride

The addition of calcium chloride to concrete quickens the time of hardening. (See Bulletin 12 of the above laboratory.) The addition of 2 lbs. of $CaCl_2$ per sack of cement adds about 40 percent to the strength of concrete two days old. Hence, the value of the $CaCl_2$ in a quick hardening concrete. While 3 lbs. of $CaCl_2$ to a sack of cement seems to give a maximum strength, the additional strength of 3 lbs. over 2 lbs. is small. Also, more than 3 lbs. starts to reduce the strength. Hence, it is deemed advisable to use about 2 percent Ca Cl_2 in making the quick hardening concrete. The calcium chloride should not be added directly to the concrete but should be made in the form of a "standard solution" of about 2 lbs. of calcium chloride to 2 qts. of water and this solution put in the drum of the mixer with the rest of the mixing water.

High Atmospheric Temperature

To secure quick hardening concrete of ordinary Portland cement, advantage must be taken of the accelerated hardening due to comparatively high atmospheric temperatures. For instance concrete cured at 40 degs. F. will have only about 70 percent of the strength if cured at 70 degs. F.; when cured at 80 degs. F. it will have about 105 percent of its strength if cured at 70 degs. F.; etc.

Time of Mix

Since the strength of concrete is increased by increasing time of the mix up to a certain limit, it is desirable to take advantage of this in producing a quick hardening concrete by extending the time of mix to at least 2 minutes. (See "Mixing Concrete" hereinafter.)

Properly Graded Aggregate and Coarse Sand

A coarse sand that meets the specification for good concrete work will produce a concrete that is stronger in its early stages than the concrete produced from the finer sand. (See Bulletin 9, Structural Materials Research Laboratory.) A properly graded aggregate also adds to the strength of concrete. Hence the extreme importance in producing this "quick hardening" concrete of having a well graded aggregate and a good quality of coarse sand.

Mixing Concrete

Only machine mixed concrete should be used. In practice, it is almost impossible to produce a uniformly maximum strength concrete, which is very imperative in repair work, if one depends on hand mixing. The usual time specified for mixing ordinary concrete in a mixer

TABLE 1—SHOWING THE MIX OR PROPORTIONS OF MATERIALS TO USE TO SECURE CONCRETE THAT CAN BE OPENED TO TRAFFIC AFTER ANY NUMBER OF DAYS

Days Patch Closed to Traffic	PROPORTIONS: Bags of Cement	Cu. Ft. of Sand (0—¼")	Cu. Ft. of Coarse Aggregate (½"—2½")	Lbs. $CaCl_2$ or Qts. of "Standard Solution"	WATER Add enough to produce slump given below	Bags of Cement per Cu. Yd. of Concrete	REMARKS
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2	1	0.5	1.9	2	1 "	11.8	This mixture to be used for small patches that are to be opened to traffic at the earliest date possible. Atmospheric temperature should average about 60° F.
3	1	0.6	2.1	2	1 "	11.2	
5	1	1.0	2.7	2	1½"	8.4	
12	1	1.3	3.0	2	1½"	7.6	
15	1	2.0	3.0	2	1½"	6.8	
21	1	2.0	3.0	No $CaCl_2$	2½"	6.8	Standard mix to be used where closing road to traffic is not an important item and where large areas are to be patched.

(5) This "Standard Solution" is made by dissolving commercial $CaCl_2$ in water at the rate of one (1) pound to enough water to produce one (1) quart of solution. The pure $CaCl_2$ should never be added direct to the drum of the mixer. The "Standard Solution" should be added to the water just before it is put into the drum. See instructions under Calcium Chloride.

(6) Standard Slump Test. Fill with concrete a metal form shaped as a frsutum of a cone. Form should be 12 ins. high with a 4-in. top diameter and 8-in. base diameter. Set the form on a level surface and as the concrete is put in the form, tamp lightly with a rod until a slight film of mortar appears on the surface. Then remove the form and immediately note the settlement of stump of the concrete which is a measure of its consistency.

is one minute. However, tests show that the strength of a dry mix may be increased as much as 10 percent by mixing one and one-half (1½) minutes, instead of one minute and the strength is slightly increased by extending the time to five or ten minutes. In repair work where there is used a small mixer which will generally be less efficient than the big paving mixer, and where a dry mix is required for a maximum strength and quick hardening concrete, the time for mixing might well be placed at not less than two minutes. Where it is extremely important that a high strength be secured at the earliest date possible and only small quantities of concrete are required, it should be mixed five minutes. This increased time of mixing will also make the finishing easier.

Placing and Finishing Concrete

Concrete should be shoveled in place and thoroughly tamped. The secret of the early strength of the concrete will largely lie in a comparatively dry mix hammered in place. A 10 lb. concrete tamper can be used for much of this work. A thin edged tamper having a face, say 1 by 4 in., should be available for tamping in narrow openings and along the edge underneath the old slab.

The concrete patch shall be finished with a straight edge, template, and a wood float, to a regular and uniform surface to fit the crown and edge of the surface of the old pavement. The straight edge should be used longitudinally on the new concrete where the patch is not too long to do so. Where a full width of pavement is being replaced for a length greater than the length of the straight edge, a template cut to the proper crown of the road should be used. This template can be used both as a cutting edge and tamper to produce a uniform surface before the mix stiffens to any appreciable extent. Too long a delay in finishing may make it impossible to make a good finish and will greatly add to the cost of the work.

Curing Concrete Patch

The great advantages of properly curing concrete are so well known that they hardly need enumerating here. The concrete containing Ca Cl_2 does not need the protection which ordinary concrete needs. However, it is best to furnish protection to the concrete with a damp cover for one-half the time the new patch is protected against traffic.

Relative Cost of Quick Hardening Concrete Made With Aluminite Cement and That Made With Ordinary Portland Cement as Described Above

Assuming that with the Aluminite cement we can use a standard mix of 1-2-3, the amount of cement required to make a cubic yard of concrete would be 6.8 bags. To make a cubic yard of quick hardening concrete from ordinary Portland cement with a 1-0.5-1.9 mix would require 11.8 bags of cement, or an increase of 5 bags of Portland cement over the Aluminite cement.

The relative cost per barrel of the two grades of cement delivered in car load lots this past year was $8 for Aluminite cement and $2 for Portland. The difference in cost is $6 per barrel or $1.50 per sack. Calcium chloride costs about $34 per ton or 1.7 cts. per lb. It is difficult to compute the cost of making and adding the standard solution. It is estimated that this costs about $2 per 100 lb. sack.

Hence the cost of the Ca Cl_2 per pound would be 1.7 cts. plus 2 cts. equals 3.7 cts. The cost factors which would vary in the making of a cubic yard of the two grades of concrete together with their amounts would be:

Concrete of Aluminite Cement		Quick Hardening Concrete of Portland Cement and $CaCl_2$	
$\frac{6.8}{4} \times \$8.00 = \$13.60$	Cost of Cement	$\frac{11.8}{4} \times \$2.00 =$	5.90
0.00	$CaCl_2$	$11.8 \times 2\text{lb} \times 3.7\text{c} =$	.87
$13.60	Totals		$6.77

$13.60 — $6.77 = $6.83

Or a cubic yard of concrete made of Aluminite cement would cost $6.83 more than if made of the quick hardening concrete of ordinary Portland cement. If the average depth of patch is 9 ins., we would be paying for the privilege of opening the pavement to traffic one day sooner, $1.71 per sq. yd.

face. At either end of such a patch a straight edge should be used longitudinally to insure a proper and uniform junction of the new concrete with the old pavement.

With a dry mix and quick hardening mix it will be necessary to finish the sur-

Further analysis of a simple algebraic formula will show if we place no value on the privilege of one day gain in setting, that the Aluminite cement would have to sell as low as $4 per barrel to compete with quick hardening concrete of ordinary Portland cement. This is also not taking into account the greater strength of the concrete made of the richer mix.

Kind of Patch to Make

There will be places in the pavement where it will be difficult to decide whether to make a surface patch with bituminous concrete or whether to cut away the old concrete and replace it with new concrete. Careful study of which method to use, taking into account all the variable factors affecting the most economical method, should be made. The men in the field will naturally insist on making that kind of a patch with which they are most familiar. Their customs and habits will guide them almost entirely. Because of their skill in making one kind of a patch and their ignorance of another, it may be even economical at times to permit them to make their favorite patch even though it would not be the most economical, if another kind of patch were properly made. This could only be true, however, if a very limited number of such patches were required.

It is believed that the foreman should be taught how to make a good cement concrete patch as well as a bituminous concrete patch. These two classes of work should not be too much for his mind to master. Perhaps no one thing in the construction world is so universally used as concrete and hence every man who associates himself with such work should master the principles involved in making good concrete.

It should hardly be necessary to warn here against letting some "old timer" make concrete patches after the old sidewalk method by putting in a dry base and letting it partly set after which it is finished with a rich mix of sand and cement. The general supervisor of such work should stop this method before it gets established. Concrete of good quality and the same quality should be used from the bottom up.

Cost of Maintaining Concrete Roads

It is difficult to arrive at accurate cost data on the maintenance of any type of road, because of the variable factors which affect this cost, such as amount of traffic, kind of traffic, miles of roads reported on, sources of material, standard of maintenance, number of years covered by the report, etc.

Relative costs, however, can be determined upon approximately, under various conditions which give some indication at least of what might be estimated for the ordinary costs of maintaining a road under similar conditions elsewhere.

The following table gives the relative average costs of maintaining the various types of road surface on the state roads in Indiana for the past two years under the conditions existing in our state. Too much emphasis must not be placed on these figures as they naturally will vary from year to year because of the variable factors affecting them. It would, of course, be necessary to estimate the relative life of the types of pavement before they require rebuilding, as well as the service they furnish the public, in order to draw definite conclusions as to the relative economic value of the different types of road surface.

Indiana
(Ave. for 1924-1925)

Brick	$212
Cement concrete	157
Bituminous concrete	379
Bituminous macadam	580
Surface treated waterbound macadam	586
Traffic and waterbound macadam	660
Gravel	651

ALIGNMENT AND GRADE AS AFFECTING HIGHWAY LOCATION

By Harry L. Brightman, Engineer of Surveys, Michigan State Highway Department, Lansing, Mich.

(Paper read at Twelfth Annual Conference on Highway Engineering, University of Michigan, Ann Arbor, Feb., 1926.)

The subject of highway location is affected by so many other considerations than the two named in the title that if these alone were considered one would be apt to get a distorted view of the subject. I have, therefore, taken the liberty to diverge from the strict interpretation of the title and look at the subject of location from the broader aspect. Again, I shall confine my remarks on the subject as it can be applied in Michigan. We have country ranging from the absolutely level plains to the semi-mountainous country. For the real mountainous country the same hypotheses will hold, although restricted by the nature of the country.

In order fully to comprehend the sub-

ject of the location of the highways of the State of Michigan one should realize that the system of highways is analogous to a great railway system, with its main lines and branches, with its double and single track. The same principles are met with in location, although the limitations are not so restricted. The problems are state wide and not local in most instances. The organization of the Mich igan State Highway Department is similar to that of the great railway with the taxpayers as the stockholders and the Highway Commissioner as the President and General Manager. The Administrative Board is the Board of Directors of the railway. There are departments of engineering and maintenance, with a Chief Engineer and a headquarters engineering staff. The Resident Engineers are the Division Superintendents of the railway. The business of the whole organization is to provide highways for the public which are as short, as direct, as safe, as easy to travel and as speedy as the various limitations, from a financial and physical standpoint, will permit. The profits or returns on the vast sums of money spent will depend upon the efficiency of the expenditure and may be measured in terms of the benefits to the citizens of the state and to the motoring visitors from other states.

Michigan Conditions

If one has before him a map showing the trunk system of the state and its connections to the trunks of other states and its relation to the newly established system of Federal roads, he is in a position to study the relative values of each line of the system and attach to each its importance. He can work toward the logical answer as to how much should be spent on each particular road for its construction, not only for the present but for the future as well, so that present expenditures will be in line with what will be required in the future and will fit into that without loss.

The state is divided into two peninsulas of different characteristics. The lower is divided into two parts which should receive different considerations. From a line drawn from Bay City to Muskegon south the country is largely industrial except along the shore of the Great Lakes. North of that line the resort and tourist business is perhaps the country's largest asset. The upper peninsula is the semi-mountainous region of the state and the mining and resort interests are geographically so closely related and the roads are so few as compared with the lower peninsula that the problem is entirely different. We have, therefore, the combined commercial and tourist traffic in the lower half of the lower peninsula, the largely tourist traffic in the upper part of the lower peninsula and the combined commercial and tourist traffic in the upper peninsula. These three different aspects will have a bearing on the prime consideration of what the road is to be used for, and the relative values of these uses in the location of the highway.

At the time the Legislature first laid out the system of trunk highways they considered the value of the system as one which would provide farm to market roads and would incidentally connect up and make through highways from town to town. The long distance travel by auto had not come into being. If one could get from one town to the next, that was about as far as he would want to go. We now have the long auto trips but we still have the old highways (excepting such changes as have been made in recent years) and the problem becomes that of further changing, adding to and rerouting the main arteries of traffic to accommodate the new condition which has arisen. It therefore, becomes a problem of careful picking and choosing to change these routes in the most logical manner and the relative value of these different routes must first be determined.

Relative Values of Routes

When considering the relative values of the different routes it is as well, perhaps, to consider them first from their engineering standpoint. This will involve an accurate knowledge of the physical geography of the state. One can tell, then, immediately how best to go from one point to the next with the greatest saving in distance and with the most directness. Having, by engineering considerations, restricted the route to a certain territory, one should then apply the acid test: the opinion of the public at large; the cost of construction; the present and estimated future requirements; the traffic which the road is to carry; the connections with other trunk routes and important local roads; the alignment and grades which are permissible or desirable. So far one has considered the route from a general standpoint. Having arrived at the general conclusions, one is ready to attack the problem from the local or specific standpoint. He must then go into details; the exact alignment, the

grades possible, the exact distance, the railway crossings, drainage conditions, soil conditions on which the stability of the road depends, stream crossings, crowded city or village streets, specific points of cost, right of way considerations, resort localities, lakes, public parks, etc.

Problems of Location

In the book of instructions for the chiefs of survey parties called "Highway Location and Surveying," I have separated the problems of location into nine different classes which are distinct and yet are so closely related that one cannot be considered without considering some of the others. The list is as follows:

1. Locations for the betterment of grade.
2. Locations for improved alignment.
3. Locations for shortening distance.
4. Locations to secure better drainage and soil conditions.
5. Locations to eliminate grade crossings of railways, either by not crossing the railway at all or by securing the proper position for a grade separation.
6. Locations to avoid the congested streets of cities and villages.
7. Locations to avoid stream crossings.
8. Locations to avoid excessive cost of construction.
9. Locations to get to the shores of the Great Lakes.

Long Units

We have made mistakes in the past by considering too small a unit for construction. We now determine two termini which are logical division points and proceed to work between them. These points average from 50 to 60 miles apart. We then take up the problems presented by these longer units, making sure that the end connections are not overlooked. The two termini may or may not have a road connecting them. If there is a road and it is fairly direct but full of curves and turns and does not pass through territory which is not suitable for road building, the problem becomes one of seeing how close we can follow the old road and improve the alignment to the modern standards. If there are places of heavy earth work and steep grades we would attempt to locate so that the grades may be reduced and the amount of earth work lessened. The work is restricted to a rather narrow area. If, however, there is no very direct road leading from one terminus to the other the investigation usually resolves itself into the study of a diamond shaped area, the two points being at the termini and the broadest part some place in between. Within this area there may be several possibilities. It becomes the duty of the engineer to search out the country from an engineering standpoint to find a route or routes which he thinks may be the solution of the problem. The general method of procedure should be to work from the outside to the center, gradually eliminating the impossibilities until the final two or three routes are chosen for a very careful study by means of preliminary surveys. These surveys are often very extensive and obtain all the information relative to the physical features of the country, such as contours, stream locations, buildings, farm boundaries, hills, valleys, railways, etc., all being platted on a map of suitable size so the costs, alignment, grades and other features may be considered. The final route is chosen and placed on the map from which it is transferred to the ground by a location survey. The work is watched as the location progresses to see that the line as projected on the map fits the ground as well as was expected.

Again, if no road at all exists, the problem is much the same only much more difficult. To me, however, that is the most interesting part of location work. Usually the country is not well developed and there is more latitude allowed. In any case the engineer will be given plenty of opportunity to use all the good judgment and common sense which he possesses. After all, the final test of a change of routes is that of public opinion unprejudiced by selfish motives. This, unfortunately, is usually not available until the route is constructed and the public has had an opportunity to use the road. There is liable to be much opposition toward a noteworthy change. If the highway engineer is not several steps in advance of the general public opinion he is not functioning to the fullest extent. If no real benefit is received by the public the change of routes is certainly unjustifiable. The engineer has to keep in close touch with the public and be very sure of his opinion before proposing any radical changes. Happily, the public is being rapidly educated in the benefits to be derived from the properly located highway and they do not look with so much disfavor upon the changes proposed as they did a few years ago.

I think the general considerations have been presented to you and we can now

attack the more specific details of location. There are three things of an engineering nature which have great effect on the location of the modern highway. These are directness, local alignment and grades.

Directness

Directness is a quality to be sought after in that it reduces the distance of travel between two points. This must be applied with caution and a thorough knowledge of the part of the country in which the road is located. In the commercial districts a direct route between two cities is very desirable. The reason is self evident. In the resort portions of the state a road which goes direct from city to city will often defeat the very purpose for which the road is built, that of taking the tourist to the points of interest which he wishes to visit. He is really in no pressing need to get from one point to the next as fast as his car will go, although to see them driving one might get that notion. In fact, if he is the true vacationist, he should be pleased to spend his time and money seeing the beauty the country affords rather than driving at top speed from one city to another. However, the people living in that section of the country as well as the tourist who is going to his home at some point far beyond use the road more in a commercial sense. Therefore we must so locate as to serve the vacationist by bringing the road as close to the desired beauty spot as the considerations of the local and through traveler will permit. The desired point of beauty can be reached by a side road of short length. In fact, many people desire seclusion and would prefer the main highway some little distance from their retreat. Again the topography of the resort regions is such that there are well defined lines through which a modern aligned highway can be put, which simplifies the broad study of a great expanse of country. So, after all, the direct highway is the one to build when one considers what may be the objective points to be reached by that highway.

Locating for Safety

We have looked at the alignment of the highway from the more general considerations. Let us, now, go into a little more detail. In our general study we have located about the general position and direction which the new highway will take. We have now to put the line on the ground most advantageously. In doing this one of the most important considerations is that of safety. Another item which must not be overlooked is that of the appearance. This item did not gain so much importance until the hard lines of the concrete pavement showed how easy it was to build a road which looked like the work of a novice instead of an engineer. Most people think that a perfectly straight highway would be the safest that could be built. Experience does not indicate that this is a fact. On the long tangent of a concrete pavement the driving becomes monotonous and hence more or less subconscious. The tendency is to go to sleep. The inducement to very high speeds is also very great. At night one can see the headlights of opposing cars for miles if the country is flat and for long distances if rolling. This makes driving dangerous. All these factors tend to diminish the safety of the road. In my opinion, the properly curving alignment is the most satisfactory. In the later surveys now being built as well as those being surveyed I have often broken up possible long tangents so as to avoid this situation. Yet when you drive the road you neither loose distance nor are you able to tell where the possible long tangent might have been placed.

Let us now go back and look at the preliminary map which we made to show us all the features which we need for the final location of the center line. Let us first suppose that this map and route follow the section line road. This is, I believe, the hardest problem which the locator has to solve. The sharply defined lines of the concrete show up every little angle in the road. We try first of all to hide them on the tops of hills. Failing that, the only solution for an angle of a few minutes is to put in a very long curve, not less than 600 ft. in length. Of course, it goes without saying that we wish to follow the section line as closely as possible as usually that will do the least damage to property. Trees, buildings and other improvements are already in place and we wish to go between them without taking them out. The long curve seems to blend with the landscape and takes away the otherwise ugly looking angle. We have some examples in this state in which this practice was not followed and the effect to one looking down the road is as though some giant had thrown the blocks of concrete and left them as they landed.

Grandpa Had an Eye for Country

Let us now suppose that the map represents one of the many angling roads which are in the state and which follow

in general the old trails made by our forefathers a hundred or more years ago. These men certainly knew their way about the country for where the old trail is followed exactly we have the real direct road which we would like to see. Of course the traffic of their day was limited to the speed of the ox cart and the angles or turns were not designed for the modern high speed traffic. They wound around to get natural grades as much as they could and followed the ridges to secure safety from Indian attacks. Yet we find, that with all their winding, we do not shorten the road much with our modern alignment. The problem here resolves itself into a process of smoothing out the sharp turns and fitting the new center line to the hills and valleys in such a way that we obtain desirable grades and alignment. One is at liberty to use all the imagination one possesses so to place the line that when the road is built it will fulfill all the requirements.

When we are studying the angling road we find that the problem is entirely different from the section line road. Here we usually have short tangents with angles varying up to 90 degs. and sometimes more. We often find that we can rearrange the old tangents and put in a long curve which will approximate the location of the old road very closely. We have carried this mapping and arrangement of tangents to such an extent that curves of amazing length can be used. We have one curve of 4,800 ft. now constructed in concrete and one of 6,700 ft. in the process of construction. We have another laid out which is about 7,600 ft. in length. These could never have been located without the map.

Flat Curves

We have come to the conclusion that the very sharpest curve to use is that of 500 ft. radius, and that this should be used only when there is no possibility of a longer one. Owing to the fact that curves sharper than 5 deg. 30 minutes are widened, which precludes the use of the finishing machine, the tendency is to make curves flatter than that. Of this kind of location we do not make the tangent distance of any curve less than 300 ft. which sometimes makes the degree of the curve as low as one minute for small deflection angles. As all curves up to a radius of 6,000 ft. are super-elevated and as the warp extends a distance of 150 ft. on the tangent, the distance between the ends of two curves of opposite direction should not be less than 300 ft. Where the curves are in the same direction this distance may be reduced some as the construction engineers can work out the warp so that it will be satisfactory. Where two curves reverse they should be as near the same degree as possible. Where two curves compound, the radius of the sharper should not be less than two-thirds of the flatter, in order to make good riding. The use of the compound curve often solves an otherwise very difficult situation. A short curve should never be placed at the end of a long tangent. In a paper of this kind it is impossible to go into details of all the rules we have for the relation of curves and tangents. I have touched on some of the more important ones only. In general one might say that the whole thought is to make the location fit the topography and to make curve and tangent so related that the driver on the road experiences no abruptness and feels at all times that he is not coming to a situation which will imperil him because of faulty location.

Vision

The subject of vision is one that cannot be overlooked and it is related to both horizontal and vertical alignment. In order that the motorist may always see far enough ahead for safety, the road should be so aligned that a clear vision of 500 ft. ahead is available. This is worked out by the long curves and the cutting away of banks which may hide the view in horizontal alignment. The vertical alignment is solved by the use of vertical curves in the grades which allow a car to be seen at a point 500 ft. distant at all times. The length of these vertical curves depends entirely on the pitch of the intersecting grades. This often requires considerable study of the grades used and a careful planning of the cuts used on hill tops. When it is impossible to cut the required amount on the hill top the fills must be increased by borrowing to give the required elevation on either side of the crests of the hills.

Grades

Vertical alignment, or grades, often make the locator use his wits to the fullest extent. In the lower peninsula, where the land is gently rolling, we have no difficulty in keeping the grades well below 6 percent. In some of the hillier portions we have difficulty in keeping grades below 8 or 9 percent. Fortunately the difficult situations occur for the most part on the less important trunks, so the steeper

grades are not so detrimental. The average touring car can easily climb an 8 percent grade in high gear, while the trucks are fully equipped with lower gears which always outlast the rest of the truck, and the heavy trucks are not used to any extent on these roads.

The question of the maximum grade to be used between two terminii should be solved first. It is obvious that if there are certain grades between two terminii which cannot be reduced below a certain maximum, it would not be wise to spend excessive sums of money to secure lesser grades at intermediate points. The maximum grade for a project must be correlated with the other features of the location. There is no set maximum grade for any road in Michigan. It is desirable to obtain 4 percent grades on the main commercial routes and 6 percent on other routes. The rolling grade is the most economical, both from the construction and operation cost. A short grade up to as high as 8 percent is not objectionable for the lighter traffic. For heavy traffic (trucks) these grades are difficult and it requires a very nice judgment to say when it is advisable to sacrifice alignment and distance for lower grades. The mere fact that a road is now in a certain position and all its difficulties have been endured by the people for many years is no reason to suppose that it should always remain there. It behooves the location engineer to study these things carefully.

It is seldom possible to reduce both grades and distance by realignment. One must be very careful to see that, in securing the lower natural grade, he does not introduce enough distance (as well as poor alignment) by which extra cost is introduced which may be greatly in excess of the cost of heavy cuts required on the old line to make desirable grades. In order to determine the relation between the two a complete preliminary survey should be made and the costs compared.

We find some very interesting situations on some of the present trunk lines. In Benzie county we have a hill with a maximum grade of 16 percent, a very crooked alignment and a grade crossing of a main line railway at the very foot of the hill. We are studying this situation now. It is one where we will have to find a new location in order to separate the highway and railway grades, without burying the village at the foot of the hill. We have run many traverses with levels and have even used the aeroplane photographs. From the air we discovered a route which escaped us as seen from the ground. We believe that we now have a reasonable and economic route over these hills, for there are two of them in the same problem. There is a crossing of the Manistee river west of Cadillac where the elevation drops 400 ft. in less than a mile and a half (appr. 16 per cent.), which is going to make somebody scratch his head. I mentioned these to show to what trouble grades will sometimes put us.

This paper will not go into details as to the laying of grades after the location is made. If we could look into the future far enough we might change our ideas in regard to the location and grades on highways. I was told recently by a member of the Society of Automotive Engineers, who is engaged in the solution of the problem of the trailer for heavy duty work, that he believed that the time is not far distant when we will see loads of fifty tons or more going over the highways in regular trains of tractors and trailers. The advance in the motor world is so rapid that what we now think is the acme of perfection in road building may seem very much the opposite within a few years. The engineer can be guided only by the vision he has of what the future may bring forth and the money which he has available for the work.

A Good Locator

We have spoken very glibly of the locator as though he were some kind of an automaton who leaves the office and presto! he is back with the road all located. Perhaps it would not be out of place to consider what kind of man is going to do all the work outlined above. To make a good locator a man should have had some experience on railroad work in positions where he had some responsibility. He should then proceed to forget most he has learned. This may sound peculiar, but the lessons learned in the railroad work will teach him the value of exactness and subconsciously he will be much better qualified in mind training for the work of highway location. However, that experience is becoming harder to get as the railroads are not building many new lines at the present time. He is handicapped by the lack of good, up-to-date books on the subject of highway location to use in his college course. Probably the best books now in existence on this subject are the instruction books put out by the various State Highway

Departments. I have had many of them and each attacks the problem from the angle of its particular state. Together they make a very good set of instructions. All of this literature will be of considerable help to a man but he will have to learn most of his lessons in the actual work. He must be born with some very necessary qualifications, for I doubt if he can acquire them. To make a successful locator a man must have a very vivid imagination. He must be able to see the new road as he walks over the country he is exploring. How will it fit this slope, how will it cross that stream, how are the swamps and hills to be avoided? are only three little questions of many which he must find the answer for. He must have a highly developed sense of direction and an exceedingly good memory of geographical locations. He must have a sort of sixth sense to keep properly correlated all the things seen on his exploring trips. He must be a student of physical geography, of geology, of petrology, and in the glaciated parts of the country a student of glacial geology. Also he should be able to name the various trees met with and know what kind of soil is their habitat. He should be a good "man in the woods," which is no mean accomplishment. To the country boy who had a chance as a child to roam the woods this is much easier than for the city boy who never had that chance. Last but by no means least he should have had experience of responsibility in the actual construction of the modern highway. This gives him the knowledge of what the construction work requires in the way of information turned in from which the plans are made. We have found that such men are rare birds and when one is obtained he should be paid according to his worth. A college education is necessary for a man to take charge of a party and execute his work properly unless he is one who has had the courage to get the knowledge required by his own efforts. To the men who located the original roads of this country we should give great respect for they made very few mistakes.

One thought I wish to leave with you is that if highway engineering is to be of value it must be thorough. Any new locations, or failures to make the needed new locations will often fix the location of roads for many generations to come. There should be no hesitation in spending whatever is needed even if it seems all out of proportion to the cost of the actual construction work to be performed within a year or so. Government programs carry out this principal and they are often criticized for the high engineering cost, but it is well worth while looking into the future. The engineering program must be complete or it might just as well be discarded entirely.

LEONARD METCALF—A BIOGRAPHICAL SKETCH

Leonard Metcalf was born in Galveston, Texas, on August 28, 1870, the son of Joseph Houghton and Emma Augusta (Leonard) Metcalf. His home for the greater part of his life was in Concord, Mass., where he died on Jan. 29, 1926. He attended the Concord High School and the Massachusetts Institute of Technology, where he took the course in civil engineering, graduaating in 1892. He was was a member of the Delta Kappa Epsilon fraternity.

For three years after graduation he was employed by Wheeler & Parks, of Boston, civil engineers and operators of water companies. He then served for two years as Professor of Mathematics and Engineering at Masachusetts Agricultural College, and in 1897 he formed a partnership with Harrison P. Eddy under the firm name of Metcalf & Eddy, specializing in hydraulic and sanitary engineering.

Mr. Metcalf's outstanding professional achievements were largely in the field of municipal water works. For more than thirty years he was actively engaged in the design and construction of water supply plants, including reservoirs, wells, pumping stations, filters and distribution systems. For years he served as manager of public service corporations, including water and electric lighting plants. He took a keen interest in the financial problems of water works properties and was nearly constantly engaged in advising owners relative to betterments of economic conditions and the adoption of sound policies which would result in adequate service to consumers and reasonable compensation for such service.

The most important of his accomplishments were in the field of valuation and rate making for public utilities. He was prominent among a small group of engineers whose clear thinking and intellectual honesty resulted in the present conceptions of the magnitude of going value and other intangible elements entering

into the value of an established public utility system; of the importance and logical estimation of the amount of depreciation suffered by such works, and the necessity for making provision for it in the rate base; and of the extreme significance, particularly in recent years, of the study of price trends and index numbers in the determination of fair values for public utilities.

As a result of the eminence he had achieved in this line of work he was frequently called upon to advise or to testify in cases relating to water works valuation and water rate making. Among the most important of these were the cases of the water works at San Francisco, Denver, Des Moines, Indianapolis, Paterson and Utica. The water rate case of the Pennsylvania Water Company of Wilkinsburg, Pa., while not of so great magnitude as some of the others, deserves particular notice because it resulted in a study of the basis of fixing rates for fire hydrant service, which has generally been accepted as the most significant and authoritative discussion of the matter which has ever been presented.

That Mr. Metcalf met these problems in an unbiased manner, and not as the special advocate of the side which employed him, is evidenced in the findings of Hon. H. M. Wright, Master in the Spring Valley case, who said: "His testimony shows not only an immense amount of labor in assembling materials for a judgment of value, but a very evident desire on the part of the witness to exercise that judgment fairly and conservatively. This must be acknoweldged whether we agreed with his final opinion or not."

A letter from Hon. Charles E. Gurney, Chairman of the Maine Public Utilities Commission, to one of Mr. Metcalf's partners, may be quoted in this connection. He said: "Among the emoluments of my present position, more attractive to me than the financial return, are some of the men I have met, whose lives and achievements inspired my admiration and an endeavor to do my best work each day. None of them has impressed me more deeply for qualities of character, a manifest integrity and a steadying earnestness of purpose than Mr. Leonard Metcalf of your firm. I always felt as he testified before this commission that there was no danger of his stultifying himself by making any statement in which he himself did not place implicit confidence. I felt that he would not exaggerate wantonly and that I could depend upon what he told me. I do not mean by this that I closed my own mind and accepted his word as infallible, but I do mean I felt that so far as human error honestly made might be excluded, Mr. Metcalf's word might be accepted and that he would not sell his opinion to the highest bidder."

His wide experience and ripe judgment in matters of this kind led to his frequent employment as adviser to capitalists contemplating the purchase of water companies.

His writings on these and related subjects, published mainly in the journals of the American and New England Water Works Association and the Transactions of the American Society of Civil Engineers and in the recently issued manual of American Water Works Practice, bear witness to the logic and accuracy of his conclusions, and of his desire to make such material available to the profession rather than to hold it for his personal use.

Mr. Metcalf's interest in his Alma Mater, the Massachusetts Institute of Technology, was constant. He had been president of the Alumni Association, and was a member of the Corporation of the Institute at the time of his death.

When war was declared in 1917, Mr. Metcalf was appointed as member of the sub-committee on Emergency Construction of Buildings and Engineering Structures, under the National Council of Defense—the committee which assisted General Littell in establishing the Construction Division, and aided in selecting personnel, making out forms of contract, providing lists of contractors, selecting cantonment sites, and awarding contracts for the cantonments erected during the summer of 1917 for the new National Army. The members of this committee were civilians. They were men who had made their mark in civil life, and whose decisions upon certain matters could not be questioned. They determined policies, and gave the military authorities the necessary moral backing to carry these policies through. This was necessary, for in the case of the cantonments, and many other projects, work had to be started before it was possible to obtain the necessary funds. It was of the greatest help for the military authorities to have the backing of a committee of well-known civilian experts which would insure them against criticisms or subsequent failure of appropriations.

His services to the profession of civil engineering have been noteworthy. He held membership in many professional societies, in most of which he had served on various committees, and as an officer. He was a member of the American Society of Civil Engineers, of which he had been Director and Vice-President; the American Society of Mechanical Engineers; the Boston Society of Civil Engineers, of which he was president in 1919; the American Water Works Association, president, 1916-17; an honorary member of the New England Water Works Association and its president in 1915, and a member of the Boston Chamber of Commerce. He took the initiative and was instrumental with others in the bringing together of the professional engineering societies of this vicinity into the Affiliated Technical Societies of Boston, immediately following the war, feeling that this would lighten their financial burdens and make more effective the work of the engineer.

He was proud of the organization (Metcalf & Eddy) which he had helped to build up, and of its contributions to the technical field in which he had worked—particularly of its three volume treatise on "American Sewerage Practice" and of the one volume abridged edition, "Sewerage and Sewage Disposal," which is now used in upwards of 60 universities and colleges in this country. He liked to think that the acquaintanceship and standing of the firm had made possible these works, to the material for which many engineers had contributed.

He was a member of the Union Club of Boston, the Engineers' Clubs of Boston and New York, the University Club of Chicago, and the Social Circle of Concord.

Perhaps the most marked and the underlying characteristic of Leonard Metcalf was his loyalty and devotion to his family—his mother throughout her life, his two sisters, and more distant relatives. His watchful care of them was ceaseless.

His keen interest, also, in the welfare of others, particularly of his professional associates, members of his staff and students whom he chanced to know, his sympathy and generosity, were recognized by his intimate acquaintances as typical characteristics.

His honesty of thought contributed to the absolute fairness of his decisions and notions. One of his precepts was "face the facts." He strove to discover them and thereafter he builded his structure upon them. This characteristic was especially marked during the last year of his life when, faced by certain death predicted with indisputable accuracy, he continued his professional practice with all the enthusiasm and vigor of former times until actually laid low by the fatal malady. Even after becoming confined to his bed, Mr. Metcalf wrote two valuable papers on rather involved subjects, for the benefit of the profession.

He believed in the practice of engineering as a profession and not as a business. His standard of professional ethics was high and, as would be expected of one of such keen sensibility, his practice accorded with this standard. He abhorred gossip and would rarely repeat even to his closest friends a rumor in the least derogatory of another engineer.

He counselled thoroughness, accuracy, refinement of detail and perfection in workmanship. While he was possessed of keen business instinct this was never allowed to dominate. On the contrary Mr. Metcalf insisted that the interests of his clients be protected even if this involved material sacrifice to himself.

Mr. Metcalf enjoyed art, travel and literature. He cultivated refined English of which he became a master. His natural clearness of vision was supplemented and accentuated by an unusual clarity of diction. He was fond of Nature and spent much time in the mountains of California and in the Colorado Rockies where he had his summer home.

His brief early experience as a teacher developed and fixed certain natural tendencies. In consequence of this, he never let pass an opportunity to point a lesson from fact, for the benefit of the younger, less experienced engineers. He was deeply interested in educational matters and was very fond and proud of the achievements of Massachusetts Institute of Technology.

His sympathetic interest, enthusiasm and optimism, tempered by sound judgment, were a source of inspiration to all who came in contact with him, particularly the younger engineers. He was an indomitable worker. His keen intellect, quickness of thought and action, and his will to work, resulted in that effective productiveness which distinguished him.

FIELD CONTROL OF HIGHWAY CONSTRUCTION

By C. E. Foster, Construction Engineer, Michigan State Highway Department, Lansing, Mich.

(Editor's Note: The following paper was read at the Twelfth Annual Conference on Highway Engineering at the University of Michigan, Ann Arbor, Feb. 17, 1926.)

Field control of highway construction in the Michigan State Highway Department consists of arranging the construction organization and facilities of the Department in a manner such that the work under construction will be uniformly built, throughout the State, in accordance with the plans and specifications. It further consists of recording such features of the construction as affect the strength and utility of structures, road bed and surface in a manner that will facilitate the intelligent study of the completed project in actual service with a view to securing more economically and correctly designed highways. To carry out these objects successfully and secure the results desired on a program of several hundred projects scattered over the State, it has been necessary to work out an organization and routine for handling the work which, to those not familiar with the magnitude of the undertaking, may seem quite involved.

The organization of the Department as it affects construction has been built up on the theory that State wide uniformity of construction can best be secured by maintaining at headquarters, a strong central office composed of men fitted by experience to lay out the work before construction, and administer it after it has been put under contract. Thus, surveys, plans and design of structures are handled in the Lansing office under the direct supervision of division heads who are held responsible for the work in their charge.

The field work is under the direct supervision of a construction division composed of resident engineers, who are in charge of groups of counties, and project engineers, who with necessary instrument men and inspectors are assigned directly to the projects under construction.

The contact of office with field is made through division engineers who, in a sense, are the direct representatives of the office in the field. By close cooperation between these men and the office division heads, it is possible for the central office to keep in close touch with the field work at all times. This arrangement is very desirable because the successful control of the work in the field is affected in a large measure by the proper preparation of plans and specifications.

The routine which has been worked out for the preparation of plans is under the direct supervision of the engineer of design who personally supervises the important features of this work. When preliminary work has been completed, the plans are taken into the field and checked on the ground by the engineer of design or one of his assistants, in company with the division engineer or resident engineer who is to have charge of the work. Every possible contingency that can be anticipated at this time is carefully studied in detail and provided for on the plans. This system reduces the number of changes in plans during construction to a minimum, and eliminates as far as possible, delays during construction which might be caused by plans not so carefully prepared. It also gives the field engineer an opportunity to study the job with plans in hand prior to construction and helps to familiarize him with the work contemplated.

The specifications for the work also affect greatly the control of the work in the field, in fact, the specifications together with plans are intended completely to control the results expected from the contractor. In order to eliminate unnecessary friction between the contractor and engineer during the progress of the work, the specifications should be definite in their requirements so that the work contemplated will be fully understood. The success of the work depends upon cooperation between the construction organization and the contractor, and, if a business basis for their dealings is provided by specifications which are obviously fair to both parties to the contract, considerable friction will be eliminated. The Department's specifications have been rewritten from time to time and it has been the object of those having this work in charge to make them as clear and definite as possible in order to accomplish this end.

The control of the construction work in the field is carried out through the field organization and the highway laboratory. The routine for carrying it out may be divided into preliminary field work, instrument work on construction, inspection of materials, inspection of work in progress, routine reports and construc-

tion records. Following is a brief description of the work as it is handled in the Department.

After the contract has been awarded, the resident engineer and project engineer, go over the job in detail with the contractor and secure from him a proposed outline of his operations, including his plant lay-out, force to be employed and other items affecting the conduct of the work. The progress schedule for the job is reviewed at this time to see that the contractor's plan for conducting the work will satisfy the requirements of the contract in this respect. After this has been done, the resident engineer goes over the job again with the project engineer and together they lay out the engineering work so that adequate service will be provided the contractor in the way of setting stakes and inspection of materials and workmanship.

The project engineer is required to set slope stakes for all grading operations in advance of the work and at the time of setting the slope stakes, he is also required to cross-section the work as a check on the original survey. As soon as the rough grading has been completed, the engineer is required to set shoulder stakes for the finishing of the grade. Likewise stakes must be set for the surfacing operations so he is not delayed by a lack of stakes. The instrument notes are carefully kept as well as all computations of earth work and other quantities to be paid the contractor. The notes are kept in a bound field book and computations made of forms provided for the purpose.

The Department maintains a highway laboratory for the purpose of testing materials used in the work. The laboratory through its own organization in coordination with the field forces arranges for the sampling and testing of all materials of construction. In order to facilitate prompt testing of materials, the routine of carrying out this feature of the work is handled directly by the laboratory through the field organization.

The project engineer is not allowed to use materials in the work which have not been sampled, tested and found satisfactory. In case unsatisfactory materials are delivered to the work, the project engineer is required to furnish reports to the laboratory and construction office routine of testing as it has been worked out precludes the possibility of unsatisfactory materials being placed in the work.

The inspection of the work in progress is one of the most important features of the field control of construction. The project engineer must be sufficiently experienced in construction work so that, under the direction of the resident engineer, he may see that the work is carried out in accordance with the spirit and intent of the specifications. On account of the multitude of his duties, it is not possible for him to be at all of the places on the job where work is in progress at all times. For this reason, it is necessary for him to have a sufficient number of inspectors under him to insure that all details of construction are carried out as contemplated.

In general, an inspector is assigned to each operation which requires for its success, definite methods of procedure which cannot be varied and still obtain satisfactory results. These men must be conscientious and experienced in their work, and must be able to command the respect of the contractor's organization. It is advisable to utilize men for this purpose who have had experience in engineering work. The work of an inspector is excellent training for promotion through the organization.

The inspector keeps accurate records of the conditions under which the work was done, records quantities of materials used and notes the workmanship employed in the construction. These records are reported daily to the project engineer, who arranges the information so collected in a manner such that it will give accurate knowledge of the job when completed. Wherever possible, materials represented by test reports are accurately allocated in the records to the points where they were used in the work. Accurate records are also kept of the weather, soil conditions and any other features which might affect the strength and usefulness of the completed work. This information is invaluable in the study of the completed project after it has been put into service.

The resident engineer, division engineer, and the central office are kept informed of the progress of the work by weekly reports submitted by the project engineer and by personal inspection of the field work.

The field organization is not permitted to change the plans or authorize extra work without first securing written approval from the central office, except in emergencies which cannot be anticipated. In this case, the division engineer is empowered to authorize the emergency extra or change. The recommendation, when it

is received from the field, describes fully the change contemplated or extra work necessary. It is accompanied by such sketches as may be necessary fully to explain the work proposed, and necessity for it. The quantities of work involved and the unit prices to be paid for the work must also be noted.

Since the change in plans or extra work affects the contract, the recommendation must also be approved by the contractor. The recommendation is checked against the plans by the designer in the central office and when approved by the chief engineer, it becomes an authorization to do the work. Since estimates for extra work or over runs of quantities can not be paid until they have been properly authorized, this method provides a constant check on operations in the field.

The careless interpretation of this requirement may cause delay of the work and therefore the central office insists, that all changes and extras, except emergencies be anticipated and authorized. This is absolutely essential in order that expenditures be kept within the budget. This system also constitutes a check on the accuracy of the original plans. A large number of changes in plans during construction should not be necessary if the original plans have been properly prepared.

The final record compiled by the field organization is a construction history, in which all of the information in regard to the construction of the project is completely described. It consists of instrument notes, earth work computations, culvert notes, inspector's diary and a summary of all of the items shown on the plans, compared with the items as finally constructed. This record also contains a narrative report which fully summarizes extra work and gives the reasons for overrun and under-run of quantities. The field computations of final quantities are checked in the office, and compared with the original plans and authorizations. When these quantities have been found correct the construction history constitutes the basis for payment of the final estimate to the contractor.

There is another use for the construction history which is fully as important as its use in determining final quantities.

In order to determine the action of the roads after they have been in actual service, we have for the past year been conducting a condition survey of roads which have been built in previous years. By comparing various types of construction under similar conditions of soil and traffic, we are able to secure accurate information to guide us in our work of design. We find we are hampered in our comparisons by a lack of accurate information of the conditions under which the roads were built, the methods followed and materials used in the work. This is especially true on the older projects. This information can be collected for a very small cost as the roads are being built and preserved for future reference.

This study of completed roads is in line with the work being conducted by a number of other states and it is the speaker's opinion that it is one of the most important features of our work today.

CORRELATION OF TRANSPORTATION AGENCIES

By C. C. Williams, Head of Department of Civil Engineering, University of Illinois, Urbana, Ill.

(The following address by Professor Williams was delivered before the Highway Short Course recently held at the University of Illinois.)

Transportation is the life blood of a nation, or of a community, just as communication is the nervous system. Let a city be marooned by a snowstorm or strike for a week and this fact becomes distressingly apparent. Groceries, meat and milk supplies and all life necessities, become exhausted in an amazingly short period. We live daily in this "hand-to-mouth" fashion without ever thinking how immediately transportation affects our vital existence. The more adequate the transportation facilities the more completely may supplies be stored efficiently in large storehouses rather than in inefficient local rooms. The vital importance of transportation renders imperative adequate facilities properly correlated in function and in operation in the first place and, in the second place, an assurance that these facilities will be designed with a sufficient factor of safety to prevent their complete failure due to the breakdown of any one of the component parts.

What are the primary agencies of transportation which should thus be correlated? Waterways, railways and highways are patently the only agencies which may be expected to carry any considerable portion of the bulk of transportation and because of the similarity and possible lapping in function, these agencies should be correlated according

to inherent characteristics and capacities so as to serve their purpose most effectively and most economically.

It is difficult to set down the essential characteristics of these agencies in any complete manner, yet a few outstanding features which affect their inter-relationships should be mentioned.

Waterway transportation under favorable conditions is slow moving and cheap per ton-mile, and restricted to a definite line rather than covering an area. It requires a considerable haul by another agency with the concomitant transfer of commodities in order that an area of territory be served. It is thus the most circumscribed and inflexible of the three agencies of transportation. It is primarily suited to hauling coal, ore, steel, stone, and similar commodities which do not suffer deterioration and whose delivery is not urgent and which can not pay a high rate.

Railroads are incomparably more effective in serving the entire area of the country than are the waterways, although even with the railways, a local haul is necessary. However this local haul is much shorter than in the case of the waterways. The cost per ton-mile is slightly greater than on waterways, and the difference would be even more pronounced, except for the adjustment of railroad rates to shield bulk commodities from sustaining their full share of fixed charges. The velocity of transit is rapid although serious delays occur in local handling of commodities. The connections with local transportation agencies at terminals is cumbersome, time consuming and productive of deterioration to commodities, and probably constitute the chief weakness of the railroads as a transportation agency.

Highways constitute the most elastic as well as the most expensive transportation agency, since they reach the door of every family and business. The cost of transportation by waterways, railways and highways for actual haulage per unit are of the scale 0.7, 1.0, 25. Indeed, if fixed charges were all accounted against highway transport, the cost would be considerably increased even over the figure mentioned.

As to reliability and safety, railroads are supreme by a large margin. For the most part, no insurance or other financial responsibility is operative to shield the patron of highway transport from bearing the loss in case of accident, although the larger companies do afford such protection. With regard to passenger traffic, on the basis of passengers killed and injured per million passenger miles, highway transport is about 15 times as hazardous as railway travel.

Now let us try to visualize the magnitude of these various agencies of transportation in the United States.

The mileage figures, 4,500 for feasible waterways, 250,000 for railways, 2,941,000 for highways give a rather vague conception of the relative magnitudes. A projection of these on the map of the United States would better serve the purpose. Imagine a waterway east and west from New York to San Francisco and one north and south from Chicago to New Orleans, and you have essentially the magnitude of our waterways fully developed. Again, imagine a steel mesh with 22 miles squares laid over the U. S. and you have a picture of the railroads. Fill in this mesh with a finer mesh of two mile squares and you have a picture of the highway mileage.

Approximately $21,000,000,000 represents the investment in railroads and about the same for highway transportation including about $14,000,000,000 in motor vehicles and about $7,000,000,000 in highways. The total operating expenses of the railroads amount to approximately $6,000,000,000 per year and the automotive operating expenses approximately twice that figure.

In the above data of waterways, only those projects which seem to be feasible are included, namely the Great Lakes-St. Lawrence system, the Mississippi river system, and the coastal canals, including Panama Canal. While some difference of opinion exists as to the extent that waterways will enter as a factor in the transportation strategy of the country, it is reasonable to assume that the next decade or two will see a considerable amount of shipping on the inland waterways. To argue that waterway operations under no circumstances can be made economical because the railroads in their aggressive days of expansion swept shipping off the inland rivers is not sound logic.

To suppose, however, that the antiquated stern or side wheel steamer will be restored to its former splendor is, of course, fatuous. It would be almost as reasonable to expect the ancient two-wheeled ox cart to return to compete with the auto truck. The modern efficient barge represents progress in shipping as do the truck and the mikado locomotive. While the Great Lakes-St.

Lawrence system, a reasonable development of the Mississippi system and certain coastal canals to facilitate coastwise shipping are doubtless feasible projects, to count on cross country canals, and the navigation of branches of the Mississippi generally would as surely be a stupendous error. The inelasticity of waterways due to their being restricted to fixed lines without branches extending to the origin of traffic circumscribes their usefulness in this age of high velocity transportation.

The railways, in contrast, form an irregular network over the country connecting all centers of population of any appreciable size. Except in the mountain and arid regions, no one lives far from a railroad. These lines at present overlap in function, compete with each other wastefully and are largely without coordination in their operation, except as economic pressure has strangled the weaklings and prospered those favorably situated. In such a random transportation machine, cost of service is a rough guess and a scientific rate structure as well as superior service through differentiation of function are impossible. However, it is reasonable to expect the proposed consolidation of railroads to proceed under the aegis of the Transportation Act until a separation of function with highly developed trunk lines, secondary lines and feeders, may be made possible. Until such unification and coordination of railroads is accomplished, discussions of correlation between highways and railways must be more or less tentative.

With the above general characteristics and data in mind, what will be the natural relationships in so far as they may be discerned between the agencies of transportation? Should legislative enactment supplement natural economic laws in preventing wasteful competition and overlapping of territory and of function? How may these agencies be best accommodated to yield the most effective and the most economical service?

In Illinois, it is doubtful if any future waterway development will have a potent influence on the highway program in general. Chicago as a port for foreign shipping will alter railway strategy, but probably not radically affect highway locations or required capacities. With the Illinois river and upper Mississippi as a water carrier, if they should develop considerable proportions in that respect, connections to existing highway routes may be easily made. Such connections would be particularly valuable, of course, as a factor of safety by making waterway-highway transportation available in the event that through strikes or other cause the railroads should be thrown out of commission. Inland waterways will never again be considerable carriers of passengers, hence, their cooperation with highways, which are primarily passenger carriers, is limited. Moreover, waterways are best adapted to hauling coal, etc., commodities which could not be hauled advantageously over highways. For these reasons, the necessity of a direct and permanent connection between waterways and highways as transportation agencies is remote.

These statements concerning waterways and highways apply generally to the nation as well as to the State of Illinois. The principal commodities adapted to waterway transport are low-rate slow moving freight, a class entirely out of the range of highway haulage. For these reasons, there can be neither competition nor cooperation to any appreciable extent, under normal conditions, between highways and waterways. Railways occupy a transportation zone lying between highways and waterways, laps and therefore competes under present conditions with both, and may cooperate with both. To find the limits of these zones of most efficient and economic operations is obviously our quest.

Transportation of persons which affords comfort, pleasure and convenience will naturally justify a high rate, hence, passenger travel on highways may be expected to be heavy. However, for long distances where a time schedule must be met, the more reliable, safer and cheaper railway will continue to be the chief agency used. One day driving marks a practical limit of distance for highway passenger travel, except for touring where economy of time is not involved. However, these limitations do not prevent highways from making serious inroads on the passenger traffic of steam and electric railways where improved routes parallel the latter. In support of this statement, the fact that, while passenger traffic per capita normally increases about as the square of the population, the passenger traffic per capita actually decreased about 8 percent in 1924 as compared with 1910. This decrease, actual and potential, was doubtless due chiefly to automobile competition. Statistics from various parts of the country clearly show a marked loss in passenger traffic due to the highways.

Long distance and commutation railroad travel have made normal gains, hence, the traffic taken by the highways is short distance, irregular travel. This situation has caused many local passenger trains to be discontinued, and others would be discontinued if regulatory commissions would permit.

Auto trucks have made no marked impression in the tonnage carried by railroads, although the effect on net revenues has been appreciable, owing to the fact that high rate commodities have been taken from the railroads by the highway. Indeed it is probable that the highways have augmented railroad freight traffic as feeders rather than diminished it through competition. L. c. l. or package freight for short hauls is being carried by trucks to a considerable extent chiefly because of the superior quality of service rendered by the highways.

A shipper dislikes to contract with a local drayman to haul his goods to the freight house, then contract with the railroad for carriage and supervise the checking and listing, and then after much delay and business of rechecking at destination, contract with yet a third party to complete the haul from the receiving freight house to the door of his house. To contract with one carrier who will make the complete door-to-door haul, and make it in a day instead of a week, with much less bother of crating, etc., is a convenience for which anyone is willing to pay a fair premium.

In general, highways are taking business from the railroads not by offering a cheaper service, but by offering a superior service at a higher cost.

With regard to the correlation of highways and railways, the subject falls under two heads; (1) transportation outside the terminal area or potentially competitive transportation and (2) transportation within the terminal area or supplementary transportation.

As stated above, definite limitations are set by the characteristics of truck operation to highway transportation generally. Surveys in Connecticut and elsewhere show that more than two thirds of truck haulage is for distances less than 30 miles and that very little is hauled more than 70 miles. Competition between railroads and highways will be generally for hauls less than 50 miles and will be for high-rate package freight. Commodities subject to rapid deterioration such as fruit, milk, etc., and those needed for emergency will properly be hauled over the highways even at considerably higher rates, because of the more expeditious service. Also highly specialized commodities which for railroad shipment require heavy and expensive packing, such as furniture, glassware, etc., can be hauled advantageously and economically on the highways for the maximum distance.

The coordination between highways and railways competitively in freight business then involves, under present operating conditions, a surrender on the part of the railways the haulage of short haul high-rate commodities. This situation makes a disproportionate inroad on freight revenues because this class of commodities is largely "the cream" of the business, and doubtless the railroads will devise means through improved service of recovering a portion at least of this business.

The coordination of railways and highways within the terminal area, the second part of the problem, offers in my judgment an alluring promise of development. The solution of the problem may be summed up in a phrase, namely, "store door collection and delivery" of freight by the railroads. Such service was in vogue in England before the days of motor trucks and has increased in importance since their advent. By instituting collection and delivery, either by a truck service under their own direction or under a subsidiary company, railroads might readily cause improved highways to be advantageous as feeders as are connecting railway lines. The railways through taxes contribute heavily to the construction of streets and rural highways, and have as good right to use them as has any other citizen, and they might do so to very great advantage to themselves as well as to the public.

A modification of equipment by use of containers or other device which will facilitate the transfer of commodities between truck and car will be necessary for satisfactory coordination, for a theoretical economic relationship between railways and highways is meaningless unless there is a physical device for making this relationship effective in a practical way.

With organized collection and delivery service railroads might, at large terminals, advantageously substitute direct cartage for railroad haul for part of the short hauls and the inter-terminal service. The cartage costs so overwhelmingly predominate in any shipment in and out of large terminals, that such shipments should carry a rate primarily based on

cartage plus a small addition for railroad haul. Obviously the entire transportation under such circumstances could be advantageously conducted by one company. Such organized cartage would act potently toward relieving the congestion of streets which results from the present haphazard individual cartage methods.

Such cooperation as is involved in collection and delivery has so many alluring possibilities, that an extended discussion of this subject alone would be justified but time does not permit, since other aspects of the general topic must be mentioned at least briefly.

One other aspect of the correlation of transportation agencies must be mentioned, namely, the relation of street railways and motor buses in cities. Electric street railways in many if not most cities in America are in financial difficulties. Securities have shriveled to one third or one half of par value and dividends are only a pleasant memory. A number of causes have contributed to this situation, such as bad financing, restrictions on fares with mounting operating cost, etc., but probably the most puissant factor is motor-bus competition.

The situation is a serious one, particularly in large cities, for the street railway is indispensable. Yet revenues at ordinary rates render its financial existence precarious. American cities largely because of the prevalence of a uniform 5 cent fare for so many years and the fact that they are planned as overgrown villages clustered about a town square, have highly concentrated and congested business districts requiring transportation of large numbers to and from such business districts daily, with the attendant unbalanced traffic.

If the street railways should cease to operate, motor-vehicles on the streets would be utterly inadequate to care for the traffic, chiefly because of lack of street capacity. Passengers in electric railway cars occupy a small fraction of the street space which they occupy if transported in private automobiles, and considerably less than if transported in auto-buses. Auto-vehicles would fall far short of the capacity required at peak load conditions in most cities of 100,000 population or more. Moreover, in inclement weather motor vehicle transportation is less reliable than street car service.

It is true that local transportation in London and some other European cities is largely provided by buses, but owing to the absence of concentrated business or industrial districts, no congestion of transportation arises to such as exists in most American cities, consequently their transportation facilities would not suffice for our conditions.

Private automobile transportation is not only inefficient and expensive to the city, but is much more expensive to the car owner than is street car transportation. This is particularly true where the owner must provide parking space at his own expense.

The accommodation of street railway service and motor vehicle transportation in cities is perhaps the most acute angle of the relationship between these two agencies of transportation, and unfortunately, a general solution is least obvious. In fact, it is probably safe to say that no general solution exists but that the situation in each city will need to be adjusted on its merits according to local conditions. In the cases which have come to my attention for special study, the removal of street cars from sparsely settled areas with the substitution of bus service seems to be a first step in the adjustment. For those who use private cars in pleasant weather and street cars in bad weather a system of fares that will throw to them a just portion of the ready-to-serve cost of street car service seems to be a next step. A realization of the community dependence upon adequate transportation and provision for social or community sharing of responsibility for the success of the transportation authorized by the community government is perhaps the third requirement. The instrumentalities for effecting this adjustment do not constitute a part of the present theme. Suffice it to say that the suggested adjustment does not transcend practical procedure.

For small cities, bus transportation with higher fares seems to be the agency best adapted because of the minimizing of fixed charges.

Urban transportation is too large a theme to be discussed exhaustively in so brief a survey, and since each city presents a case for special study, only general lines of procedure are suggested above.

Any discussion of a correlation of transportation agencies would be incomplete without a reference to regulation. Most of the states attempt regulation of bus and truck companies by requiring a certificate of "convenience and necessity" from state authority, for the operation of transportation lines over the high-

ways. In many states, whether there exists adequate transportation by steam or electric railways is an essential consideration in determining the propriety of issuing such a certificate of convenience and necessity. In at least three states no restriction is placed on competition with railways on the part of highway transport agencies. Such lack of regulation can result only in serious economic loss eventually with corresponding inconvenience to the public.

Generally, state regulation of highway transport is placed very appropriately in the hands of the state public service commission. It is probable that in the case of highway operation affecting interstate commerce the time will come when a more complete regulation of interstate routes by Federal authority will be found desirable, just as the concentration of railway regulation has gradually shifted from state to Federal authority.

Even rural highways have ceased to have a primary relation to agriculture, for improved highways are located to connect cities and are primarily avenues of commerce rather than mere aids in marketing of crops. Whatever the Federal control of highway operation it should be under the same bureau that regulates railroads. The Department of Commerce through the Interstate Commerce Commission is a more logical instrumentality for regulating highway operation than is the Department of Agriculture. Likewise state regulation of bus and truck companies doing intra-state business should be under the control of the same body that regulates intra-state steam railroads and electric and street railways. Both state and Federal regulatory bodies will need to act vigorously if a period of serious economic waste through improper competition is to be avoided.

Let me summarize briefly in conclusion.

1. Of the three agencies of transportation, railways occupy the middle zone, and overlap both waterways and highways to a certain extent, requiring adjustment with both. Waterways and highways at opposite ends of the transportation scale have no direct connection of prime importance.

2. Railways constitute the chief agency of freight transportation, except for package high-rate freight for short hauls. Railways will be forced to surrender much of this business and to readjust their methods in order to minimize the amount surrendered.

3. Highway transport will inevitably compete with the railways for passenger traffic, particularly for distances within a day's ride. Long distance and commutation passenger business will be carried by railroads, the former because of economy and the latter because of street congestion.

4. For urban transportation electric railways are indispensable in large cities; in medium cities, street railways are necessary but will have to be fostered by the community if they are to prosper; in small cities, the street railway in most cases may be forced to retire from the field before the elastic, low-fixed-charge bus service.

5. The proper correlation of these agencies of transportation requires a concentration of control. State and Federal control should be in the same bodies which are charged with the regulation of railways, both steam and electric.

Adequate transportation is essential to community life, either local or national, and to secure the most effective utilization of the agencies available, it is necessary to understand their natural spheres of operation and to adopt a certain amount of artificial regulation in order to prevent wasteful competition and to promote most efficient cooperation and coordination.

RECENT DEVELOPMENTS IN TRANSPORTATION

By George E. Patterson, General Manager, Illinois Central Railroad, Chicago, Ill.

Although transportation has kept its place for ages as one of man's greatest necessities, the conditions under which it is produced have been and are constantly changing. No man can afford to be dogmatic about transportation. What may seem permanent in one generation may appear exceedingly unstable in the next. It therefore behooves us to keep our eyes open, perpared to give careful consideration to each new transportation development that arises. That is good individual policy and good public policy.

The highway is unquestionably the oldest artery of transportation. Its origin is lost in the mists of antiquity. Explorers endeavoring to find out how the ancient Egyptians were able to assemble the great stones for building the pyramids were astounded at the remains of the roads they discovered. The Chaldeans

and the Babylonians could not have built their great cities and magnificient temples without good roads. Rome was "mistress of the world" largely because of her fine roads, many of which have endured to the present day.

The railroad is the outgrowth of the highway. As early as 1550 the Germans operated push cars on wooden rails in their stone quarries. Similar contrivances were used in collieries of England in the eighteenth century. The first steam locomotive was built in 1784, but it was operated on a public highway instead of rails. The first steam locomotive to be successfully operated on rails was built in 1825. It is interesting to note that two and one-third centuries passed between the introduction of rails in the quarries of Germany and the introduction of the first steam highway locomotive in England; and nearly half a century then passed before the steam locomotive was successfully operated on rails. One hundred years ago last September the first trip was made by a steam locomotive on rails drawing cars loaded with freight and passengers and that marked the real beginning of the railroad.

Following the introduction of the steam locomotive, the growth of transportation by railroad was rapid. The first locomotive that was brought to America arrived in 1829. In 1840 there were 2,800 miles of railroad in the United States; in 1850 there were 9,000 miles; in 1870 there were 53,000 miles; in 1900 there were 190,000 miles, today there are more than a quarter of a million miles of railroad in this country—approximately one-third of the total mileage of the world.

It was not the operation on rails that was responsible for this great expansion. Cars have been operated on rails for around 375 years. It is to the steam locomotive that we owe the rapid and extensive development of railway transportation in this country and throughout the world. It is doubtful if any other one invention has had such a revolutionary effect upon mankind or such a stimulating effect upon human progress.

What the steam locomotive has meant to the railroads the automobile has meant to the highways. In 1895 there were only four automobiles in this country. Ten years later—in 1905—there were 77,400 passenger automobiles and 600 motor trucks; after another ten years, in 1915, there were 2,310,000 passenger automobiles and 136,000 motor trucks. We now have in this country apporximately 17,500,000 passenger automobiles and 2,500,000 motor trucks and the output of the motor vehicle manufacturers in 1925 was 4,325,000 cars.

The automobile gave a great impetus to the improvement of the highways. In 1904, when automobiles were just coming into widespread use, expenditures for highway construction in this country amounted to around $60,000,000. Now our highway expenditures are running close to $1,000,000,000 a year and we have approximately one-half million miles of improved highways in this country—enough improved roads, if they were so laid out, to form 166 magnificent highways reaching across the continent between New York and San Francisco.

While this extraordinary development has been going on in connection with highway transportation, the railroads have not stood still.

During the last two decades first track railway mileage increased from 218,000 to 250,000 miles and the mileage of all railway tracks increased from 307,000 to 410,000 miles. The number of locomotives in use increased from 48,400 to 69,400 and their aggregate tractive power increased from 1 billion 129 million to 2 billion 544 million pounds. The total freight car capacity of the railroads increased from 53 million to 101 million tons. The money invested in railway properties increased from 14 billion to 23 billion dollars. The average load carried per train increased from 308 to 647 tons. The number of passengers carried one mile increased from 22 billion to 36 billion, and railway freight traffic increased from 175 billion to 388 billion ton miles.

In other words, while we have had this extraordinary growth in the use of automobiles in highway transportation, the railroads on the whole are today far ahead of where they stood twenty years ago.

Railway progress in recent years has been intensive rather than expansive, has been in the direction of greater efficiency and greater capacity rather than in the direction of increased road mileage. In the early stages of railway development the expansion of the railroads was measured largely by the extension of their mileage. But as time went on and the country settled up, the need was not so much for additional mileage as it was for increased facilities in the territory already occupied; therefore, railway development in recent years has consisted largely of increasing the capacity and

efficiency of mileage already in existence through second, third and fourth tracks, sidings and yards, heavier rail, ballast, signal and other safety devices, more substantial and more durable bridges and structures, enlarged shop facilities, reduced grades and eliminated curves, more powerful and more efficient locomotives and improved passenger and freight equipment.

Although railway progress on the whole has continued at a substantial rate, nevertheless the increased use of automobiles has affected the railroads. In some respects the effect has been detrimental and in other respects beneficial to the railroads. Long-distance travel by railroad has continued to increase, but short distance travel has fallen off substantially because of the convenience of using private automobiles. It has become necessary for the railroads to discontinue the operation of many local passenger trains because of the declining patronage and the continued losses which the operation of trains entailed. Transportation of freight by motor truck has increased considerably but the motor truck has its limitations as a freight carrier. It is best adapted to the handling of short-haul traffic. As a connecting link between the railroads and off-line communities, the motor truck has been an aid rather than a detriment to the railroad, and the same is true of passenger-carrying motor vehicles. There are more bus lines running between points that do not have direct rail connections than there are between points that are already well served by the railroads. Then, too, there is the vast traffic which the railroads have derived from the handling of automobiles and parts, gasoline, road-building machinery and materials, and so on. In that respect the railroads have been helped. If we could weigh the benefits against the detriments, I believe we should find that the railroads have gained a good deal more than they have lost from the development of highway transportation.

There is absolutely no danger of motor vehicles ever supplanting the railroads to any large extent. Motor trucks will handle more or less short-haul, package freight, but they will never handle any considerable amount of bulky, long-haul freight, and it is the latter which constitutes by far the larger part of the nation's commerce. The situation is analogous to wholesale and retail merchandising. The railroads are wholesale dealers in transportation: motor trucks are the retailers. The average carload of freight on the Illinois Central System consists of about 36 tons. It would require more than 7 trucks loaded to 5 tons each to transport our average carload, and it would require 360 motor trucks loaded to 5 tons each to transport the tonnage that can be hauled in a 50-car freight train.

Railway and highway transportation should co-operate with each other and co-ordinate their efforts. Both are performing essential service, and there is plenty of room for both forms of transportation. There are some cases where both forms of transportation cannot be justified by the needs of the territory and both cannot thrive. These cases call for adjustment. The fixing of rates, the taxation of highway common carriers in proportion to their use of the highways and other matters of like nature will in time be equitably adjusted so that the railroads and motor vehicles operated as common carriers will be on equal footing.

It is to the advantage of the railroads to encourage the conntinued development of the highways and the increased use of automobiles just as it is to the advantage of those engaged in the highway and motor vehicle industries to encourage the continued development and prosperity of the railroads. After all, the railroads form the backbone of the American transportation system and produce a system that we could not get along without. The railroads consume about one-quarter of our coal output, one-third of our steel output and large amounts of many other commodities. They spend approximately five billion dolars annually for labor supplies, and approximately one-seventh of our population is directly dependent upon them for a livlihood. Railway prosperity means prosperity in all lines of industrial and commercial activity. Everyone, regardless of his particular field of activity, regardless of his business or profession, should be interested in the railroads.

The foregoing address by Mr. Patterson was delivered at the recent Short Course in Highway Engineering at the University of Illinois at Urbana.

TRUNK HIGHWAY MAINTENANCE IN MICHIGAN

By B. C. Tiney, Maintenance Engineer, Michigan State Highway Department, Lansing, Mich.

(Paper read at Twelfth Annual Conference on Highway Engineering at the University of Michigan, Ann Arbor, February, 1926.)

The evolution of the motor vehicle carried with it, logically, a great development in methods and organizations for maintaining roads. Not many years ago, the condition of country roads was a matter of interest mainly to the farmer. Now it is a matter of concern to the city as well as the rural resident.

In the days of horse-drawn traffic the necessity for maintaining roads was not so apparent, and the idea was prevalent that when a new road was constructed, little need be done to it for several years. Modern motor traffic has clearly demonstrated that maintenance must begin as soon as construction is completed, and continue systematically throughout the life of the road.

The trunk line highways of Michigan represent a capital investment estimated at approximately $100,000,000. The purpose of our trunk line maintenance organization is to protect this large investment, to maintain these roads in such condition that they will render maximum service to the public, and to keep pace with growing traffic demands by occasional betterments to the original construction.

We are, and for several years have been, faced with the necessity of accomplishing this purpose with limited funds. Our maintenance ambitions seem to be about 30 to 40 percent higher than our ability to finance. By increasing the efficiency of our organization and by using more modern equipment and methods, we will be able to approach nearer to our idea of one-hundred percent maintenance, but experience has shown clearly that it will cost about $4,000,000 annually properly to maintain the present 6,900 mile trunk line system of Michigan.

It might appear, upon first thought, that owing to the progress of our paving construction program, there should be an annual reduction in the cost of maintenance. This tendency is, at present, far over-balanced by the annual increase in traffic and by an increasingly critical demand, on the part of the public, for more refinement in the work. The motorist demands highway service, and rightfully, because through the gasoline tax, he is paying for that service. When maintenance appropriations are increased to the extent of providing dust layers and adequate resurfacing on all of the gravel roads, and snow removal for wheel traffic on all trunk lines, then the progress of the hard-surface construction program may combat the increase in traffic to the point of showing an annual decrease in maintenance cost.

The scattered nature of maintenance work makes its proper supervision more difficult than that of construction. While construction operations are usually outlined quite rigidly by specifications, the varying conditions in maintenance work are such that it cannot be as readily covered by specifications, and the maintenance superintendent is compelled to draw on his judgment and experience in many cases.

The maintenance superintendent must be in close touch with his foreman and patrolmen. He must see his roads and traffic often enough to have personal knowledge of conditions and to know how his organization is functioning. Provision should be made for telephone communication between the superintendent and his foremen or patrolmen. Special traffic, such as that of holidays and Sundays, must be anticipated and preparation made to give it service. Bituminous surface treating of gravel and macadam roads should be so scheduled that it will least inconvenience the users of the road. On some of our roads, the traffic is so heavy as to seriously reduce the efficiency of maintenance labor and it is good policy to withdraw the gangs from such sections on Saturdays or other special traffic days.

It is very desirable that as many experienced maintenance men as possible be employed through the winter, as this avoids the trouble and expense of constantly educating new men. The repair of equipment and the increase of snow-removal work is making it possible to offer steady employment to an increasing number of men and thus raise the standard of this labor.

Road maintenance work is always under public observation. In our experience, there is a certain part of the driving public who care little about the methods, organization or cost of the work as long as we give them good results. Others, however, are interested in the efficiency of the labor and equipment used, and they

should be given no cause for just criticism. Any employee who is inefficient or who does not use discretion and courtesy in his contract with the public, while on the work, has no place in a maintenance organization. The proper location of headquarters for gangs and patrolmen will eliminate much loss of time in going to and from the work.

A maintenance organization should be sufficiently flexible to take care of necessary work at the proper time and to handle every emergency. The superintendent who does not, for example, patch a section of road until a month or six weeks after it should have been done is inviting a just criticism from the public. Careful thought should be given to scheduling the work so that such delays will be eliminated. It frequently happens that insufficient equipment or lack of experienced foremen to direct additional help prevent the doing of certain work when it should be done. The public, as a general rule, sees only the fact that they are required to travel a road which is not receiving proper care.

One object of the re-organization of the Michigan State Highway Department this year was to provide more adequate supervision of the maintenance work. In our previous organization the resident engineer had charge of both maintenance and construction in his territory, with the result that maintenance was frequently neglected and the most of his time spent on construction. The new organization provides ten Maintenance Supervisors, each having charge of maintenance only, with an average of about 700 miles of trunk-line road apiece. The men selected for these positions were, for the most part, those who had shown an interest and ability in maintenance work. The new organization makes possible at least 50 percent more maintenance supervision that the Department had available last year. It is believed that the highway engineer who is specialized on maintenance will give it keener study and accomplish better results that he would if part of his time was spent on construction. He must not lose sight of the fact, however, that a back-ground of construction experience is necessary for the maintenance engineer.

The action of our last legislature, in providing that the construction and maintenance of state trunk lines should be entirely financed by the state instead of the previous cooperative payment plan with counties, will tend toward greater uniformity in the maintenance of these roads. Obviously, a state trunk line road, serving through traffic, should be under central control, and should receive a degree of maintenace justified by the traffic, regardless of county lines.

The township roads, which are at present maintained by small township organizations whose officers are changed frequently, could be more economically maintained by the central county organization. It is believed that future development will tend to eliminate the township maintenance organization and place this work in the hands of the county organization.

The State Highway Commissioner has contracted with 67 counties for the performance of the 1926 maintenance work, while state force-account maintenance organizations will be placed in 15 counties. In one county, the work will be divided between the contract maintenance organizations of two adjacent counties. In many cases, the work of a contract county is not confined to the limits of that county, but is extended into the adjacent county on certain routes, where a continuation of the same type of road, more convenient location of headquarters or other reasons have made such an arrangement seem advisable. This should result in economy and more efficient operation of patrol equipment.

The major materials to be used on trunk lines maintenance work this year will be purchased by the state, for contract counties as well as for state organization counties.

Large quantity purchases should result in lower prices than counties would be able to obtain by purchasing individually. All minor materials and some of the major materials which are produced locally will be purchased by the counties.

Touching briefly on the method of maintenance accounting; the contract counties will submit semi-monthly statements of pay-rolls, equipment rentals, and material purchases, distributed to the proper classification of work and to the maintenance sections on which the work was done. These statements will be summarized monthly, approved by the Maintenance Supervisor and forwarded to the Lansing office where they will be audited and paid. Payrolls and material bills in the state organization counties will be paid directly from the Lansing office after being approved by the Maintenance Supervisors.

The classification of work has been changed somewhat, this year, in order to conform to the recommendations of the American Association of State Highway Officials. It is believed desirable to have a standardized classification of work in the various states, for the purpose of comparing costs. In the new form, Dragging and Patching will be separated. Snow Fence will not be included in Snow Removal but will be reported under Structures. Betterments will be separated from Maintenance proper. Under Betterments will be included such work as widening the original metal or roadbed, increasing the original thickness of metal, eliminating sharp turns, placing guard rail or culverts where none previously existed, or replacing any structure with a larger structure. Initial bituminous surface treatments of macadam or gravel roads are regarded as Betterments.

A proper office organization is very important in keeping the costs on maintenance work. Information as to the amount spent on each maintenance section should be available at all times to guide the superintendent in making further expenditures from the budget as set up for each section. Accurate costs of the various operations are valuable in making estimates for future work, and the total cost, considered in connection with the traffic census, is used in computing the vehicle-mile cost of maintenance by road types.

Many of our older gravel roads were built under a specification which permitted stone up to 2½ in. in size, and when these surfaces are worn down they are very difficult to maintain. The high crown which was built into the older roads causes the resurfacing gravel to work to the edges under traffic. To correct these faults, the road is scarified to practically its entire depth, the large stone raked out and the remaining gravel reshaped. The equipment generally used for this purpose is a 10-ton caterpillar tractor and a heavy grader with scarifier attachment. It is easier to scarify the entire depth of gravel than to attempt to scarify only a partial depth. After scarifying, the gravel is sometimes harrowed, to further pulverize it and bring the large stone to the top. The stone over one in. in size are usually raked out by hand, but one of our counties has developed a mechanical rake which greatly reduces the cost of this work. The oversized stone should be hauled away and not left along the shoulder where the patrol graders are liable to work them back into the road. After the gravel has been reshaped to proper cross section with the heavy grader, it consolidates quickly under traffic. In fact, traffic is but little inconvenienced by this work, as a section of from ½ to 1 mile may be completed in a day by one outfit. A light resurfacing of clean fine gravel and the application of a dust palliative add an excellent finishing touch to the surface. The cost of scarifying, raking and reshaping is generally from $60 to $100 per mile. The use of this method is increasing in the state, and we regard the heavy tractor, and grader equipment as almost indispensable to the proper maintenance of gravel roads. The investment in equipment is further justified by the use of the tractor for snow removal.

It is probably true that in breaking up the old crust and removing the large stone, the road is rendered less stable during the early spring break-up, but we believe that this is more than offset by the improved riding quality and greater case of maintaining the surface during the balance of the year. It is not recommended that a road be scarified late in the fall.

Our further experience with bituminous surface treatments on gravel roads indicates that this is a desirable method of serving heavy traffic until such time as pavement construction can be financed. One hundred twenty-two miles of gravel trunk lines were maintained in this manner in 1925. In this work we have adhered largely to the method of sweeping, as in the treatment of macadam roads, but will probably try, on a few sections during the coming year, the dragging method which is much used in Wisconsin at this time. We have used cold application materials entirely for the first year treatments and the bulk of our work has been done with tars. Last year we gave one road a second-year treatment with a heavier, hot-application material with very satisfactory results. It would appear that the mat thus produced has sufficient body to be carried for at least two years without re-treating, and at the same time is not so thick that it will wave under traffic.

A feature of winter maintenance which is increasing in importance in the southern part of the state is the work of relieving the slippery condition of pavements, especially on hills and curves. The

methods used have been to melt the ice from the pavement with calcium chloride or cover it with a thin layer of sand. Our experience with calcium chloride would indicate that it is liable to scale a concrete pavement which is of recent construction, but does not seem to affect an older concrete pavement. We have, at times, many miles of road which are in a hazardous condition for traffic due to ice coating, but it seems improbable that we will do more than treat the hills and curves, for some time.

During the past three weeks the work of snow-removal for wheel traffic has been extended north to the Straits of Mackinac on four main trunk lines, adding about 700 miles to our snow removal system. For the first time in the history of the state these roads have been passable for through motor traffic in the winter. The business and social life of these communities has instantly responded to this connection with the open roads to the south. The equipment placed on this work consists of one heavy tractor-plow unit and one light truck-plow unit on each section of approximately 50 miles. We realize that this is not sufficient to give immediate service such as is warranted by traffic in the industrial regions further south. This equipment, however, is operated day and night when necessary, and we will be able to open practically all of these routes within 24 hours after storms.

Our Maintenance Supervisors are at present noting the location of drifts with a view to placing snow-fences for next winter, and it will be possible to eliminate much heavy plowing by drift control. The proper location of snow-fences must be studied, from year to year, until the most effective position is found. Recent observations show that some of our snow-fences are not functioning while others are saving a great deal of money in snow removal. We anticipate that during the next few years the amount of snow fence used in the state will be increased by many times the present mileage.

PLAYGROUNDS GAINING IN BEAUTY

By Weaver Pangburn, Playground and Recreation Association of America, 315 Fourth Ave., New York, N. Y.

Barren playgrounds all over America are blooming into beauty spots this year. One hundred and eighty-two cities in 42 states have entered 312 playgrounds and athletic fields in the national playground beautification contest conducted by the Playground and Recreation Association of America. The $3,000 in cash awards offered by the Harmon Foundation and $1,650 further awards in the form of nursery stock have stimulated entries. But cities have adopted the idea with enthusiasm for reason other than awards and national fame. They realize that the bleak, ugly play space is a poor advertisement and that the contest provides an excellent objective for civic endeavor.

The South leads all other sections in the number of entries to the contest. One hundred fourteen play field were entered by 53 cities. New York leads the states, with 27 entries from 16 cities, Illinois being second with 26 entries from 15 cities. Memphis gained the distinction of entering more playgrounds than any other city, with 17 entries. New Orleans entered ten grounds, Fort Worth, nine, and Reading, eight.

An interesting feature of the contest is the number of small communities enlisting. Nine villages of less than 500 population have elected to beautify playgrounds, which in most cases are connected with rural schools. Antreville and Coward, S. C., each boasting 100 residents, are the smallest. There are many other entries from towns of one or two thousand. New York City is the largest city to enter.

The small cities will not have to compete with the larger, as the awards will be equally distributed among three population groups, as follows; less than 8,000 population, 8,000-25,000, more than 25,000. The leading playground in each of these groups will receive $550, the ten playgrounds next highest, $100. Not the most beautiful playgrounds will win, but those which have made the greatest progress in beautification by November, 1926. Hence the most unsightly ground stands a better chance to win than one which is somewhat attractive at the outset.

Children are being enlisted in the campaign as a means of encouraging nature study and pride in the playground. Shutting in playground noises through skillful planting and adapting the ground to the neighborhood are considerations.

Among the organizations cooperating are women's clubs, Parent-Teacher groups, the American Legion, men's luncheon clubs and various horticultural societies.

STANDARDIZATION OF CAST IRON PIPE

A standardization project of far-reaching importance is about to be inaugurated through the formation of a representative Committee on Cast Iron Pipe which will undertake a general program of unifying existing specifications for cast iron pipe into a consistent set of nationally recognized specifications. This committee, which will be officially known as the Sectional Committee on Standard Specifications for Cast Iron Pipe, is being sponsored by the American Gas Association, American Society for Testing Materials, American Water Works Association and New England Water Works Association and will function under the procedure of the American Engineering Standards Committee.

This development is the outcome of the submission two years ago by the American Gas Association of its Standard Specifications for Cast Iron Pipe and Special Castings to the American Engineering Standards Committe for their approval as American Standard Specifications. It became evident that consideration of these specifications for such approval would involve the standardization of cast iron pipe in general, and at a conference held under the auspices of the American Engineering Standards Committee, which was very widely representative of industries that produce and use this product, it became clear that whereas dimensional standardization was principally involved in the specifications for gas pipe, a broader treatment of the whole problem was essential if results of the greatest benefit were to be obtained. Thus at this conference the need of a study of the quality of metal in cast iron pipe and the problem of suitable coatings were emphasized as ones of primary importance to water works engineers. Recently developed methods of producing cast iron pipe must be taken into consideration. The American Gas Association was entirely willing to have the project broadened, and upon the recommendation of the conference the American Engineering Standards Committee agreed to set up a broad program of standardization of cast iron pipe under its auspices and invited the American Gas Association, American Society for Testing Materials, American Water Works Association and New England Water Works Association to sponsor the organization of a representative "sectional committee" to carry on the actual work of investigation and standardization.

The scope of the work has been defined as follows:

Unification of specifications for cast iron pipe, including materials: dimensions; pressure ratings; methods of manufacture (including such new developments as centrifugal casting), in so far as they may be necessary to secure satisfactory specifications; elimination of unnecessary sizes and varieties; consideration of the possibility of developing a coordinated scheme of metallic pipe and fittings applicable to all common mediums; and methods of making up joints in so far as they are determining as to the dimensional design of cast iron pipe.

The types of cast iron pipe to include; bell and spigot pipe; flanged pipe; flanged and bell mouth fittings and wall castings; pipe elbows, tees, Y's, return bends, and other fittings not now included in standard lists; cast iron pipe threaded for flanges or couplings; soil pipe and other light types of cast iron pipe and fittings. The standardization is not to include methods of installing pipe and similar matters, except as to the making of joints in its relationship to the dimensional standardization of pipe and fittings, as noted above.

The sponsors have been engaged in the This stage of the work is practically committee, which will comprise representative producers and users of cast iron pipe, and independent technical experts. Eleven technical societies and associations are represented in the work of the committee. This sage of the work is practically completed and the sponsors announce the personnel of the committee as follows:

The formation of this committee brings together for the first time the major technical societies interested in the various phases of the cast iron pipe problem and it is confidently anticipated that the co-operation of the producers and consumers upon the broad basis thus made possible will result in the development of national standards of quality and dimensions acceptable to all.

Plans for the formal organization of the committee in the near future are being made and will shortly be announced.

LABORATORY CONTROL OF CONCRETE AGGREGATES

By Roger L. Morrison, Director Michigan State Highway Laboratory, Ann Arbor, Mich.

(Paper read at 12th Annual Conference on Highway Engineering at the University of Michigan, Ann Arbor, Feb. 17, 1926.)

The quantity of aggregates used by the Michigan State Highway Department is much greater than that of any other material, as they form nearly 90 per cent of the concrete bridges and culverts, and the concrete and bituminous pavements, and 100 per cent of the gravel roads. During the year 1925, the Department used approximately 24,000 carloads of aggregates in concrete bridges, culverts and pavements, 1,700 carloads in bituminous pavements, and 13,000 carload in gravel roads, making a total of 38,700 carloads. These cars would form a solid train reaching from Detroit to Chicago, a distance of nearly 300 miles.

With this in mind, it can easily be understood that insuring the quality of these aggregates is a very important matter. This vast amount of material is produced under varying conditions in numerous plants all over the state and it is only by careful inspection that the quality can be kept up to standard.

Reasons for Specifications

So far, the Laboratory has been concerned primarily with the control of concrete aggregates, and it will probably be sufficient to discuss them in this paper.

The first step in obtaining proper aggregates is, of course, the drawing of the specifications. As it is one function of the Laboratory to assist in preparing specifications, the reasons for some of the provisions will be considered.

The specifications are frequently taken more or less for granted by the less experienced field men, without much attempt to analyze the reasons for the various provisions and as a result it is sometimes difficult to form a sound judgment as to whether certain materials on the border line should be accepted or rejected. In fact, if the young engineer attempts to find a book which will interpret aggregate specifications, he will search in vain and it is the lack of available information on this subject which seems to justify a brief discussion of some points which may be entirely familiar to the majority of engineers.

If the sand is not clean, the cement will not adhere to it properly and the resulting concrete will not be as strong as it should be. Lumps of clay will not make good concrete though a small amount of clay and silt does no particular harm if evenly distributed and not in the form of lumps or a coating on the sand grains, hence it is customary to permit two to three per cent. In fact, it is practically impossible to eliminate all clay and silt from sand. A small amount of organic matter in the sand may cause a serious failure of the concrete. For instance, shipping a sample of sand in a sugar or oat sack may destroy its tensile strength, as will small amounts of decayed wood or oily shale. Unless the sand is hard and durable the grains will fracture under traffic and break out, leaving the concrete surface pitted. Crusts or hardened material may not break up in the mixer to form mortar.

When it comes to the grading of aggregates, there is enough difference of opinion among experts to cause anyone to hesitate before making any dogmatic statements, but there are certain things which are generally accepted as facts. One is that with given proportions of cement, water and sand, coarse sand will make stronger mortar than fine sand. Hence the specification that not more than 95 per cent shall pass a 10-mesh sieve. On the other hand, it is sand that we want for fine aggregate and not gravel, so we say that at least 95 per cent must pass a ¼-in. screen, while the 20-mesh and minimum 10-mesh requirements are added to give a uniform grading and low void content, thus presumably increasing the strength of the mortar. If the sand does not contain at least five per cent of particles passing a 50-mesh sieve, the concrete will not finish easily and this requirement would be raised to ten per cent if such sand could be generally obtained.

"The proof of the pudding is in the eating" and therefore, we say that when tested in comparison with standard Ottawa sand, which is of uniform size (20 to 30 mesh) mortar made with the sample sand shall be at least as strong as that made with the standard sand. Tensile rather than compressive strength is tested in this case, because the former test is more easily made, the results are more consistent, and the compressive strength varies approximately as the tensile strength.

Much that has been said regarding fine aggregates applies also to coarse aggregates. Thin or elongated pieces are more easily named than defined and it is doubtful if their exact effect upon concrete is known, but they are apt to break easily and form excessive voids so that they are believed to be harmful. Few aggregates are entirely free from such material, and the percentage which warrants rejection is a matter of opinion.

As nearly all gravel deposits in Michigan contain more or less soft sandstone, keel (clay ironstone), and similar materials, it is practically impossible to eliminate them entirely, and this situation is recognized to the extent of permitting as much as two or three per cent by weight. The exact effect of this material is not known as yet, but the Laboratory is now making a series of tests of concrete specimens containing varying amounts of soft stone. It is believed that excessive amounts of each material decrease the strength and wearing qualities of concrete, at least indirectly by requiring more water to produce a given slump, and the extra water is harmful. Soft stone tends to "float" to the surface as the concrete is placed and it is then liable to be disintegrated by frost and traffic. Pieces of shale in the surface are knocked out by traffic and leave pits. These pits frequently have a small amount of shale left in them which clearly indicates their origin.

The use of unscreened aggregates is not permitted because of the difficulty of keeping the proper ratio between the fine and coarse aggregates as furnished and the danger of segregation of sizes in handling.

Specifications Cover Material When Used

The laboratory places inspectors at aggregate plants when the quantity furnished by the State amounts to as much as ten cars a day, but it is sometimes necessary for the engineers to reject aggregates on the job which have been passed by the plant inspectors. This practice has been frequently referred to by contractors and aggregate producers as "double inspection" and has been strenuously objected to by them. Such objections to so-called "double inspection" are, however, based upon a misunderstanding of the situation.

In the first place, the specifications form a part of the agreement with the contractor and cover the materials at the time they are placed in the mixer. It would be entirely logical under the contract to have all inspection performed on the job, even right at the mixer skip, all unsatisfactory material being rejected at the last moment only. This, however, would involve a great expense in freight and handling charges on rejected material and frequent annoying delays to the work. To reduce such expense and delays to a minimum, the State places the inspectors at the plants to stop unsatisfactory aggregates at the source. In other words, the inspection is essentially at the job, but a man is put at the plant to keep poor material off the job so far as he is able to do so.

Difficulties of Plant Inspection

As a matter of fact, there is very little material which has to be rejected on the job after it passes the plant inspector, but it is extremely doubtful if plant inspection of aggregates can ever be made 100 percent perfect. In the case of such materials as cement and steel, samples can be taken in a specified manner from each car and every sample can be tested, so that when a car is once approved there is no reason for subsequent rejection, except possible deterioration from some cause after shipment.

Unfortunately, however, aggregates are not susceptible to such exact plant inspection methods. As an extreme case, there is one plant which has a capacity of about 200 cars daily. This would be an average of a car every seven minutes during a 23 hour day, if shipments were at a uniform rate, and with a much smaller daily output, the rate of loading may be as fast, or even considerably faster, for a few hours a day. As it takes at least ten minutes to sample a car properly, and nearly two hours to make a complete test of a sample, it is absurd under such conditions to say that an inspector's card on a car should be considered as a guarantee of quality and that all further inspection should be eliminated. What actually happens is that one inspector watches the car as it is filled and if it looks all right he signals another inspector who tacks on the card. Five minutes later the car may be half a mile down the track and thirty minutes later it may be on the main line headed for the job. In some other case, aggregates are loaded and shipped at night which of course makes plant inspection still more difficult.

The above discussion should dispose of the "double inspection" bogy and demonstrate the necessity of inspection on the job, even where the cars bear plant inspectors' cards.

The Production of Aggregates

Having shown what plant inspection cannot accomplish, the next thing to do is to show what it can, and does, accomplish. To make this clear it may be desirable to describe briefly the construction and operation of such plants for the benefit of those who may not be familiar with them.

Most of the aggregates used in Michigan consist of sand and gravel and the plants for their production consist primarily of gravel pits, screens, conveyors and bins. A detailed description of the various types of plants is beyond the scope of this paper, so that only those most commonly used will be considered.

The gravel is usually loaded from the bank with steam shovels and hauled to the screening plant in cars. It is dumped through a large screen or "grizzly" into a hopper, from which it is carried to the top of the plant on a conveyor belt. It then passes through a series of revolving screens fitted with water pipes and is washed while it is being screened. Stones too large to pass the specifications are crushed and then passed through the screens; after being screened and washed the gravel and sand are dropped into bins, each bin containing aggregate of a certain size, or sometimes it is dropped into stock piles over a loading tunnel. From the bins or stock piles the materials go to loading bins where the different sizes are combined in the proper proportions, or other methods may be used for getting the proper combination. The loading of cars for shipment may be done by means of loading belts or through gravity chutes.

Starting Plant Inspection

When the Laboratory is notified that a plant is shipping as much as ten cars daily to a state highway project, an inspector is sent to the plant. Before a new man is sent out as a plant inspector, he is drilled for at least a week in the Ann Arbor Laboratory in the testing of aggregates, and if possible is taken to nearby plants to observe their operation, or he may serve for a short time as an assistant inspector under a more experienced man.

When he receives an assignment, the new man, together with his equipment, is taken to the plant by the chief inspector.

Upon arrival at the plant the equipment is first checked and set up by the new man, and he is instructed in its use under the handicaps of location outside the laboratory. The standard equipment consists of the necessary screens and sieves, 2,000 gram capacity scales, 200 c. c. glass graduates, a supply of sodium hydroxide and bottles for organic matter tests, a trowel, counter brush, drying pans, large spoons, sample sacks and stationery. A small oil stove is required if there are no facilities at the plant for drying aggregates.

After the equipment has been arranged, the pit is visited and the chief inspector points out possible sources of trouble, such as excessive overburden not removed, clay pockets in the bank, parts of the bank containing an excess of fine material, old stumps, possible oily shale ledges, or other sources of organic matter. This study of the pit puts the inspector on guard against the particular difficulties which may arise from that quarter.

From the pit the inspector is taken to the top of the screening plant. As a rule he can get a birdseye view from there of the entire layout of pits, tracks, waste piles, etc., which gives him a clear idea of the general system of operation.

Next the material is followed down through the plant and the screening and washing methods are studied. Such items as possible overloading of screens, insufficient water supply, etc., are noted. Special attention is paid to the arrangements for combining sizes and loading cars. The attention of the new inspector is called particularly to points where segregation may occur.

After this examination of the plant a conference is held with the plant superintendent and suggestions are made as to possible methods of eliminating sources of trouble. For instance, arrangements may be made for additional stripping work to reduce the amount of clay going through the plant, the steam shovel may be moved to another part of the pit, the rate of feeding the screens may be reduced, more water may be used in washing, or washing may be done at additional points, arrangements for combining sizes may be improved, baffle plates or other devices may be installed for reducing segregation in loading cars, and one or more men may be put to hand-picking soft stone from conveyor belts. By such methods the quality of the product can often be greatly improved with very small expense to the producer.

The new inspector is then ready to begin work and he is first taught how to sample cars. This is one of the most difficult operations in the whole field of highway materials inspection, and a care-

lessly taken sample may not come anywhere near to representing the actual average contents of the car. Incidentally, it seems rather like wasted energy to argue over fine-haired differences in screen sizes until the general methods of sampling and handling materials can be so rigidly specified that reasonably consistent results can be obtained on different samples taken from a single car of gravel at different times.

The method used by our laboratory in sampling cars is to dig "shoulders" on about six or seven of the "waves" formed by the movement of the car in loading. About three of these shoulders are usually dug in the center of the waves and the other four about half way between the center line and the side of the car, half of them being located on each side of the center line. Samples are then taken by digging into each shoulder, and these samples are placed upon a piece of canvas. After thorough mixing, the combined sample is quartered, if necessary, to get a single sample of the proper size. Some additional digging should be done to detect the possible presence of sand cores at some distance below the surface.

Last year Mr. W. E. De Young made a detailed study of sampling methods and the results of his investigation may be found in the Proceedings of the 1925 Michigan Conference on Highway Engineering.

After learning how to sample the cars properly, the new inspector is given additional instruction in making tests under plant conditions, in making reports, etc. Usually the chief inspector remains at the plant for a day or two until everything is running smoothly, and then he makes frequent visits to it during the construction season.

Routine Inspection

The routine inspection consists of doing from day to day more or less of the work which has been outlined above, the exact routine depending upon varying conditions at the different plants. As a result of his tests, the inspector soon becomes sufficiently familiar with the aggregates being produced so that he can make a fairly accurate estimate of the grading by watching the loading of the cars. Whenever it is possible to do so, he samples about a third of the cars, and then tests the samples at such times as the plant is not loading cars for State work. It is evident that the majority of the cars must be passed or rejected on the basis of visual inspection only. This is not complete inspection so that, as previously stated, additional examination, and possible rejection, at the job does not constitute double inspection.

Once each week the inspector tests a sample each of fine and coarse aggregate and then sends the samples in to the Laboratory, together with the results of his tests. Check tests are made there and if there is any appreciable variation in results the inspector's testing methods are checked up.

One of the greatest difficulties with which the inspector has to contend is the formation of sand cores due to segregation in loading. The fine material often drops immediately to the bottom of the car and remains in place while the coarse material rolls to the side. As these sand cores are at the bottom, it is difficult to detect them after the car is loaded. Every effort is made to watch for their formation and to eliminate them by correcting improper loading methods, and the installation of anti-segregation devices, but in spite of all efforts they will sometimes "get by" the plant inspector, without being detected.

The assistance of the field engineers is earnestly solicited by the Laboratory in completing the inspection of aggregates. Any material obviously unsatisfactory should be rejected without hesitation, a sample and report, including car number and date, being sent to the Laboratory for record and so that the situation can be brought to the attention of the plant inspector. Questionable shipments should likewise be sampled and reported, and, if possible, held until the Laboratory can make an investigation.

A word should be said in regard to the excellent cooperation which the Laboratory has received from the producers. Last year several representatives of the Highway Department attended the annual meeting of the Michigan Gravel Association, explained some of the things we were trying to do, and requested suggestions from the producers. The Association appointed a committee to meet with a Department committee at Ann Arbor, and many points were discussed at the committee meeting. This resulted in a better understanding by each side of the aims and problems of the other side, and during the season of 1925 there was not a single controversy which was not settled amicably, and to the satisfaction of both parties.

NEW DELAWARE RIVER BRIDGE AT PHILADELPHIA

By Russell Byron Williams, 6437 Kenwood Ave., Chicago, Ill.

Back in 1816, two engineers by the names of White and Hazzard, erected the first wire-cable suspension bridge in the world. The dusty records covering this engineering project say: "This was a foot bridge across the falls of Schuylkill, above Philadelphia, whose cables were of 6 wires, ⅜ in. in diameter, and so a new epoch of development was instituted. The span of the structure was 408 feet; its cost was $125; a toll of one cent was charged for passage, and only eight passengers were allowed upon it at a time." Thus did Philadelphia start something—then finish it, 110 years later, by erecting the world's greatest wire-cable suspension bridge, which now spans the Delaware River and connects Philadelphia with Camden, Pennsylvania with New Jersey. This new structure will be officially opened to the public, July 4, 1926,—150 years after the signing of the Declaration of Independence.

One cannot think of crossing the Delaware River without having his mind revert to the troublesome days of 1776. Thomas Paine it was, who said in a letter written to George Washington, during the early part of that year: "These are times that try men's souls." Paine's words took on added meaning with each month that followed, reaching their climax perhaps on that famous Christmas night when Washington, then a captain, took 2,400 illy-clad and half-frozen men, horses, guns and paraphernalia, across the swift and treacherous Delaware River that was filled with cakes of floating ice—surprised the drunken Hessians and took 950 prisoners, besides killing 17 and wounding more than 80 of the enemy. This he did at a cost of only two men and four wounded and in spite of a driving storm of snow and sleet which rendered useless much of his ammunition. Then, as a fitting climax to his successful daring, he recrossed the dangerous and icy Delaware that evening with all his prisoners and captured guns.

A great steel wire suspension bridge would have meant much to Washington and the cause of independence in 1776. With a total population in the 13 colonies of 2,810,000 (about as many as are now in the city of Philadelphia alone) it was obviously impossible to have such a bridge even if the necessary funds ($32,738,000) had been available—which they were not. Indeed, 150 years ago, there was no such thing as steel or galvanized wire, and cables 30 in. in diameter were not only unnecessary, but, by reason of that fact, undreamed of.

But the progress of the intervening century and a half, made possible by the republican form of government instituted at such pains and privations and the subsequent development of mechanical methods and then unknown products, has brought about the serious need for the bridging of the Washington-famed waters—which need is now being met with the erection of the longest suspension bridge in the world. This bridge is 9,500 ft. in length, 135 ft. wide, 385 ft. high, and with a suspension span of 1,750 ft. It is, in itself, an outstanding example of the progress of the American people in 150 years; an example of the vastly differing conditions and circumstances between 1776 and 1926. And on July 4, next, during the sesqui-centennial celebration of the signing of the Declaration of Independence at Philadelphia, an electric button will be pressed which will open to vehicular, trolley, rapid transit and pedestrian traffic between the two cities, this largest of all suspension bridges, the mother of which stood across the Falls of Schuylkill 110 years ago.

From the engineering standpoint the new Delaware Bridge is a twentieth century marvel. It excels in every way all previous records in bridge building. Heretofore the Brooklyn, Williamsburg and Manhattan bridges held first place in suspension bridge construction. All of these, however, have been eclipsed in almost every dimension by the new Delaware River bridge. Instead of being hung by two cables formed of six strands of ⅜-in. wire the new bridge is suspended by two finely woven, steel wire cables, 30 in. in diameter (18,666 strands of No. 6 wire each). Rather than being limited to 8 foot-passengers at a time the new bridge will accommodate 6,000 automobiles an hour, in company with four lines of rail traffic and two 10-ft. streams of pedestrians. The live load is calculated at a maximum of 12,000 lbs. per lin. ft. of bridge, while the structure itself, being more than a mile and a half in length, will add enormously to the weight that must be suspended by the two cables. Indeed, the tensile strength of each cable is 223,000 lbs. per sq. in., or something over 100,000,000 lbs. per cable.

All of the wire used in the weaving of these enormous cables, if stretched out in a single piece, would total 25,100 miles —sufficient to encircle the earth at the equator and have enough left over to reach from Pittsburgh to New York. This wire was merely wound into large reels at the factory of the Page Steel & Wire Company, the weaving into cables being done right on the job. When it is remembered that each cable has 18,666 wires, that each is 3,540 ft. long and weighs 6,750,000 lbs., this task of weaving the cables in place takes on enormity. More so, perhaps, when it is realized that the laying of the strands and the weaving of the cable must be done in such a manner that not a single wire must be allowed to shirk its strain, thus throwing added burden on another wire. That this was done, and done perfectly, however, was assured by Chief Engineer Modjeski when he said: "In such work there is always the danger of a wire or two slipping and the accident not being discovered until we come to the squeezing process with the 'traveling spider.' Not one wire, however, has failed to fall into its intended place and the contractor is to be congratulated on the performance of the work of his wiremen. All wires pull together."

The suspender ropes supplied by the American Cable Company and extending from the two main cables to the floor of the bridge, number 596. These alone have a total weight of 7,400 tons. The floor which they support is made of steel and reinforced concrete, there being on it, two 10-ft. sidewalks, a 57-ft. motor drive, two trolley tracks and two rapid transit tracks.

Suspension bridges date back to the obscurity of Chinese history. The first mention of suspension bridges was made by Kircherns in his "China Illustrata" published in 1667, wherein he describes a suspension bridge consisting of 20 chains, which, according to him, had already seen more than a century of service. Among the earlier suspension bridges is the one over the Danube at Budapest, which has a span of 666 ft., and the Clifton Bridge at Bristol, England, having a span of 702 ft. Both of these bridges, however, are of chain. It remained for Philadelphia, in 1816, to erect the first wire-cable suspension bridge across the falls of Schuylkill—thus ushering in a far-reaching development in bridge construction—then complete what she had started with the erection of the Delaware Bridge, which will take its place immediately as the principal factor in the future growth and development of the two cities and surrounding territory.

PURCHASING SAND ON TONNAGE BASIS

By T. H. Walton, Jr., Stewart Sand Co., Kansas City, Mo.

In response to a number of inquiries, we have conducted a series of tests to determine the amount of loss to the customer when buying sand on rainy days. First, when buying sand by the ton; second, when buying sand by the cubic yard.

We have made daily tests for several weeks, under all possible weather conditions, to determine the following facts: We have found that sand (1 ft. from surface of pile) will contain a minimum of 50 lbs. of moisture to the ton regardless of the period between rains. Also that sand in a pile will never contain more than 100 lbs. of moisture to the ton. After this point is reached rain will run off as fast as it falls. Thus it can be seen that the greatest possible loss per ton to the customer on account of additional weight of the sand in rainy weather is 50 lbs. to the ton which is 2½%.

However, we have found that sand rarely dries enough to contain only 50 lbs. of moisture to the ton. Several tests made on sand that had dried from 2 days to a week showed 60 lbs. of moisture to the ton. Tests made during a light rain and 2 to 4 hours after a heavy rain showed a moisture content of 90 lbs. to the ton. Under these conditions we find the average amount of extra water delivered to our customer will not be more than 30 lbs. or 1½%.

Every contractor or foreman on a concrete job has observed that moisture in sand caused it to bulk or increase in volume. At the same time it was no doubt observed that proportions which gave concrete of the desired workability one day with one lot of aggregates, gave concrete that was harsh and difficult to handle another day. This can easily be traced to the "bulking" of sand.

Sands which run from dry sand to sand containing 5% of moisture will have increasingly greater bulk so that the same number of grains of sand which fill a 1 cu. yd. of measure when absolutely dry will occupy 37 cu. ft. when containing 5% moisture.

Our tests have shown that sand in a pile contains from 90 to 100 lbs. of water to the ton on wet days. This amount of water in the sand will cause it to bulk the maximum amount. When the moisture content of 1 ton of sand is increased from 50 lbs. (the minimum amount found in sand) to 100 lbs. (the maximum amount), the sand will occupy one-tenth more space.

From the foregoing it is evident that the customer not only does not lose anything on wet days when buying sand by weight as compared to measure, but actually gains. The greatest possible loss when buying by weight is 2½% of the load and the loss when buying by measure is 10% of the load, a difference of 7½% of the total amount purchased.

Sand measured by weight gives as nearly as is practical a uniform amount of dry sand under all conditions. When sold by the yard there will be a considerable variation in the actual amount of dry sand in each load. For this reason we have placed all our sales on a tonnage basis.

THE ECONOMIC CASE FOR ZONING

By Noulan Cauchon, President of the Town Planning Institute of Canada.

We all plan our private undertakings, we plan our houses, our business offices and our factories; the interests which lend money for financing these undertakings—loans on residences, office buildings, stores and on factories—pre-suppose their proper planning and efficiency as a collateral security for the realization of the sums loaned.

Does it not seem strange that we abandon these wise methods just on the threshold of the greatest undertaking of all, the collective correlation of all these individual factors into an organic community?

Surely if it be logical to plan our individual concerns we should realize that it is a still greater necessity to plan and correlate our collective activities if only for the reason that the lack of planning in the larger undertaking so often destroys the fruit of planning in the smaller and more individual concerns. If the city is planned correctly an individual aberration does not put the city out of gear, but however well the individual effort may be planned the machine will not function properly as a whole if these individual efforts are not collectively correlated to function together organically. Your hand may be maimed, and still your body may function by reason of its general organic efficiency, but our present cities are very much like a body composed of quite well-designed parts and limbs without a collected nervous and muscular system under brain control.

We must guard against the idea that a city will grow "naturally" or that the law of supply and demand will adjust the proper relations to these things. The term growth is a biological term which implies a control in the development of part and function balanced by the inherent virtues of the life force. The city is not a biological organism, it is a mechanical contraption and, therefore, requires as a machine does, to have a "governor" or artificial control, which will prevent this mechanism from running wild and being helplessly subject to alternative choking congestion or to bursting of its fly wheel.

One of the first elements to control in civic development is the density of population under home living conditions and also the intensity of distribution of its productive activities. It is only when these conditions are satisfactorily determined and controlled that the factors for their maintenance can be calculated in accordance with the necessary demands; that is, it is only when an engineer knows the areas and their uses and densities that he can say with any approximation to accuracy, how wide and how many and in what direction the necessary streets should exist and that the size and capacity and general scheme of sewers, water mains and gas mains and all the other public services can be efficiently and economically established.

For the stabilization of conditions, both as to their amenity and as to the preservation of their negotiable values, there must be what is popularly known as zoning, that is, living areas must be protected by law from the haphazard incursion of other purposes, such as stores, laundries, public garages, etc., in fact of any incongruous feature which disturbs and depresses the quiet and peacefulness so much desired and needed for the home atmosphere. The reverse of the matter is that in so far as commrcial activities are permitted to wander from the business streets into residential districts they not only destroy the residential values, but they subtract from the value of the com-

mercial streets by withdrawing a measure of their exclusive advantage as places of business, thereby diminishing the assessable and negotiable values on business streets.

It is important to realize that under our modern economic system, undertakings, from the building of a home to that of stores, offices and factories are of necessity and progressive advantage financed by some capitalist, trust and loan company or other moneyed interest. The development of a city depends in measure upon the ease with which the individual, the merchant and the manufacturer can get money for his purposes.

Zoning, which means determining the use and development of land and protecting it from unwarranted intrusion and disabilities, thus protects the owner in his peaceful possession to best purpose, enabling financial assistance for development on the collateral security of stability in purpose and development.

As an example take an ordinary individual of modest means—and he is the majority who has saved say $5,000; he wishes to establish a home on the basis of a $10,000 property. He borrows half the value of that property. The loaning agency has a security of 50-50. No sooner is his home built in an *unzoned* city than a garage or a laundry, or a pioneer store is opened up on the adjoining lot. Immediately the value of the home becomes depreciated by at least 25 per cent in its negotiable value. Thereby the city loses an assessable value, the loan company has lost half its margin of security and should the house be sold the owner has lost half of his life's savings. This is a quite common injustice of circumstance in any or in every city which is not zoned.

Now let us multiply the case of the individual just mentioned throughout the city and it will easily be seen that about a quarter of the total value of a city which is not zoned is in constant jeopardy of needless and aimless depreciation.

It should be easily realized that in a zoned city it will be easier for the individual to borrow money for the building of his home or business because of the stabilized security behind a loan, and also it will be more desirable and more attractive for the loan company to lend money in zoned cities where their margins of securities are protected. In the larger fields of civic borrowing loan companies and all the great interests which underwrite bond issues will inevitably come to view with more favor those cities which can offer the collective stability of zoning behind their civic loans.

Beyond these business considerations zoning is primarily based upon the biological demand for an environment that will maintain health and efficiency. The object of zoning is to stabilize desirable purposes and healthfulness, efficiency, amenity and values, not to crystallize conditions.

COMBINING TRUCK AND INDUSTRIAL RAILWAY HAULING ON HIGHWAY WORK

By T. J. Weidner, Secretary and Treasurer, George S. Mellert-Weidner Co. Medina, Ohio.

The combination of a sandy subgrade and wet weather gave an opportunity to emphasize the advantages of the combination haul plant under such conditions on one of the jobs which our company did last season in Ashtabula County, Ohio.

The particular work in question was 12 miles of 16 ft. concrete road with an average thickness of 7¼ in.

The job was not awarded until late in July and inasmuch as it was desired to complete as much of the work as possible before the close of the season, it was decided to put two outfits to work.

On August 10th we started at one end of the job with our combination haul plant. A 21-E paver was used and materials were hauled on trucks in batch boxes from the central proportioning plant to a transfer where the boxes were lifted off the trucks and placed on narrow gauge cars for delivery to the mixer past the green concrete.

It may be of interest to some to know that the transfer device which we used was entirely home made. It was a design of one of the members of our firm, Mr. L. J. Westland, who acted as Superintendent of the work.

This transfer consists of an "I"-beam across the road carried on two "A"-frames. A hoist carried on a trolley on this "I"-beam was operated by a Ford engine placed at one end of the transfer.

The entire transfer cost about $1,000 and proved to be quick and economical. We could transfer a box from trucks to cars or vice versa in a little less than one minute.

At the beginning of operation the mixer started at the transfer point and about

two miles were laid when the transfer was moved ahead as far as the concrete was cured sufficiently to allow trucking over it. As the work progressed, this transfer was continually moved ahead so as to allow trucking over the new concrete as far as it had been open to traffic.

Our haulage equipment consisted of Lakewood track, cars, and batch boxes together with two seven-ton Plymouth locomotives. On the maximum haul we used three trains which consisted of eight cars and sixteen boxes.

As a direct basis of comparison, we started on August 20th with another outfit on the same job. This outfit was identical with the first one as far as the subgrading, mixing, and placing equipment was concerned, but the hauling was entirely done by trucks.

A large portion of the subgrade was sandy, while in other places it was entirely of clay. Very often it was necessary to plank over the subgrade for the trucks because even the light trucks would almost bury themselves, necessitating rebuilding the subgrade and even resetting the forms. The sections of clay subgrade were particularly bad in wet weather and a great many rainy days were encountered during the time the work was in progress.

This condition of the two plants working on a job where conditions of hauling equipment, type of work being done, etc., were identical and the only variation in the plants being in the method of haul, gave good opportunity for a direct comparison of the combination haul plant and the motor truck plant under such circumstances.

It was necessary to shut all of the work down before it could be completed, on account of cold weather setting in. However, the combination haul plant, which started work August 10th, completed seven miles. The motor truck outfit, which started work only ten days after the combination plant, completed three miles.

In comparing these figures, it must be remembered again that the conditions of the weather and subgrade were such as to make the truck haul plant difficult to operate, but did not affect the combination haul plant.

There is no question but that the combination haul outfit in the majority of instances will give greater production than the truck haul outfit for the same length of time. The reason is that the combination plant, where all hauling is done over good roads and with narrow gauge, is not compelled to shut down because of weather conditions to the extent of the truck haul outfit.

Naturally the gain in production with the combination haul plant, due to greater time it will work, will be affected by the weather encountered and by the character of the subgrade over which hauling is done. It is true that sometimes conditions might be encountered where a truck haul plant would show to just as good advantage as the combination outfit. For instance, if a new road were being built over an old macadam base, the delays to the trucks from weather would not be so serious. Again, a season might be encountered with few rainy days.

But all in all, comparing one against the other for average conditions, it can be said with positive assurance that more working days per season can be expected from the combination plant.

There are certain other intangible factors which make the combination haul plant a producer of better profit to the contractor. There is a saving of material because it is possible to maintain exactly with the combination plant the required depth of subgrade. With the truck plant, the subgrade once prepared is rutted and cut up, making retrimming necessary, increasing the amount of concrete required, and adding to the labor costs. Neither is it possible to keep the subgrade as well rolled, the rolling operations being interferred with by the passage of trucks.

Again, with the combination haul plant, forms once set are not disturbed by trucks crowding them up or out of line. Roads can be built smoother, with less hand work behind the finishing machine as a result, and the work can be done cheaper and better.

As a result of our own experience with trucks and narrow gauge, we are firmly convinced of the economy and advantages of the latter.

TAXATION OF ELECTRIC RAILWAYS FOR HIGHWAY USE

(Editor's Note: The following is an excerpt from an article entitled "Urban Aspects of Highway Finance," contributed to the February, 1926, issue of "Public Roads" by Jacob Viner, Professor of Political Economy, University of Chicago.)

It is the common practice in American

cities to levy a privilege tax on electric railways for the privilege of using the city streets, or to require them to construct and maintain at their own expense the paving within the track space and for a specified distance on each side. They are also required in some cities to remove the snow and to sprinkle the streets on which they operate. The item "receipts from highway privileges," amounting in 1923 to $26,700,000, includes amounts received from electric light, telephone, and water companies for the privilege of using the surface or subsurface of streets for their structures and equipment, and also receipts for the privilege of maintaining vaults under the streets; fruit, gasoline, and other stands on the streets; and awnings, signs, etc., extending over the sidewalk. But a large portion of these receipts consists of amounts paid by electric railways for the privilege of using the streets.

In 1919, after which year the Census Bureau returns ceased to differentiate between the various types of highway privileges, the revenue from charges for the use of space on or under the highways by privately owned public utilities, mainly electric railways, amounted to 93 per cent of the total receipts from highway privileges, as compared to 7 per cent from charges for the use of space for miscellaneous special purposes, such as awnings, gasoline pumps, signs, etc. It has been estimated, also, that the annual cost to American electric railways of rendering the paving services required by their franchises exceeds $20,000,000. This probably includes the item amounting to $7,211,000 for 1923 of compensation to city highway departments for repair and construction services, most of which undoubtedly came from electric railway companies which, instead of doing their own paving, had it done for them at their expense by the municipal highway departments. In a few cases, as for instance Chicago, the city also receives a share of the receipts of the surface railroads.

The electric railways make, therefore, a substantial annual contribution to the cost of urban highways. Their representatives, in fact, complain that they make too large a contribution, especially as compared to motor transportation, and that this discrimination in taxation operates as a subsidy to competing methods of urban transportation. They protest especially vigorously against the paving requirements, which they characterize as an obsolete survival from the days of horse cars, when the horses did actually wear out the pavements.

There is no evident reason why electric railways should contribute more heavily in proportion to their use of city streets than other types of transportation, and it is in fact desirable that competing types of transportation should bear the highway costs properly attributable to them in proportion to their use of the highways, in order that their relative capacity to render transportation service should be tested under equal conditions. The fact that electric railways are common carriers, whereas private automobiles are not, should have no bearing on the question, since the special privileges enjoyed by a common carrier are granted in the public interest rather than in the interest of the carrier and are accompanied by special and onerous obligations and restrictions. But if electric railways are being required to make too great a contribution to highway revenues, it is only true, if true at all, in comparison with other types of transportation. In so far as the paving and snow removal requirements are concerned, they are clearly arbitrary and have no necessary relationship to the costs to the cities resulting from the operations of electric railways. Under existing conditions, electric railways should be required to meet the highway costs incurred by the cities on their behalf to the same degree as such requirement is imposed on other types of vehicular traffic using city streets.

In so far as paving is concerned, it is proper to attribute to electric railways such increase in the costs of construction and maintenance of pavement as result from the presence of tracks and the operation thereon of street cars. How this increase can be computed is a problem for the engineers, but the type of test suggested by some engineers, namely, a comparison of the paving costs on two streets of similar width, one with and one without street car tracks, is clearly defective unless the character and volume of vehicular traffic on both streets is constant and unless the same standard of maintenance is applied to both streets. But in large cities, and especially in the congested portions thereof, space utilization is a more important economic factor than the wear on pavements, and a thoroughgoing apportionment of highway costs would take into account the comparative utilization of space of the different types

of carriers as well as their wear on the pavements.

ILLINOIS HIGHWAY PROSPECTS FOR 1926

(Editor's Note: Much anxiety has been evident for months with reference to the Illinois State Highway construction program for 1926. In spite of many obstacles and numerous difficulties of a varied nature, the engineers and officials in charge still confidently expect to pave at least 1,000 miles of road this year. A good discussion of this subject is reproduced herewith from "Public Construction News," official organ of the Illinois Association of Highway and Municipal Contractors.)

"What are the prospects for highway work?"

"How do things look at Springfield?"

"When are they going to let some state work?"

Such are the questions which are being fired at us from all angles. They are vitally important questions, too, from the standpoint of the contractor, who is becoming restless after a rather gloomy winter. In the past the contractor could console himself through the winter by contemplating the thousand miles or more which would be let. He could kill a little time attending the lettings, even if he didn't come away with a job. But the winter which is just now passing into history has been one of the most uncertain and pessimistic seasons of retirement which we have experienced in many years. Have we gotten to the stage where we expect a thousand mile program every year? It looks that way. But these thousand-mile years can't go on indefinitely, and we may as well accept the fact now as later.

There is at least one consoling thought to be salvaged and that is that even though we don't have another record breaking year in Illinois during 1926 the roads must be built sooner or later and what we don't build in 1926 we will build in 1927 and subsequent years. Who knows but what the gods of fate are being kind in keeping us in a barren pasture? Judging from the bidding hysteria in evidence throughout Illinois, both on highway work as well as municipal construction, perhaps we are better off not to have any work rather than to have a great volume at the present prices. We harbor the opinion that if some of our over-zealous contractors are forced to a starvation diet for the season it may clear their vision and bring them face to face with the fact that they cannot go on forever doing work "to keep the organization together" or to "get a job for the outfit." Should it have this happy effect the sacrifice will not be too great. A lean year may not be so bad after all if it purges the industry of some of its price butchers.

For six months we have stood agog awaiting the solemn dictum of the Supreme Court in the notorious "Virginia Case," which will remain fresh in the minds of Illinois roadbuilders for many years. That decision has been handed down and a more favorable decision on the disputed contention could hardly be asked for. As stated by Mr. Sheets, it is most sweeping in its scope and should definitely settle for all time the powers of the Division of Highways in making changes of location in the construction of the state highway system. To all who are familiar with the details of the case it is most logical that this power should be conferred upon the state's highway engineers without interference from selfish individuals or communities. But contrary to opinion which is all too prevalent, the decision in the Virginia Case does not by any means clear the path of all obstructions. By far the large majority of undecided sections are being held up pending the settlement of right-of-way disputes. Many property owners seem to look upon this as an opportunity to exact exorbitant prices in payment for new right-of-way. It will probably be necessary for the courts to decide what constitutes fair compensation in such cases. But this will take time and is poor consolation for the contractor who must sit idly by awaiting the court's decision.

The most encouraging development recently has been the announcement made by Chief Highway Engineer Frank T. Sheets before the Short Course in Highway Engineering at Urbana, February 15, when he stated that the State of Illinois would not be thwarted in its plans to continue the construction of highways on a large scale. He stated that the Division of Highways was determined to take steps which will place it in position to begin the letting of contracts on the Hundred Million Dollar Bond Issue Roads within sixty days, and that every effort which it was humanly possible to exert will be made with this end in view. There

certainly should be some way to bring this about, as it isn't reasonable that a few selfish communities can throttle the great State of Illinois in its program of highway construction. We have every confidence in the highway officials of the state and know that nothing will be left undone to work out a satisfactory solution to this problem.

In viewing the situation generally, the outlook for a fair mileage of highway construction during the coming season presents a more favorable aspect at present than it has for some months past. In our opinion the 1926 program hinges almost entirely on the state highway department carrying out the plan indicated by Mr. Sheets in the announcement referred to above. If a practical and legal method can be evolved for disposing of the unawarded balance of the Sixty-Million Dollar Bond Issue Roads within the near future we can see no reason why Mr. Sheets cannot proceed with the letting of the initial sections of the new Hundred-Million routes. If such a plan can be perfected and executed the quicker it is done the quicker we will know just what we can expect during the 1926 season. Developments within the next month or six weeks should indicate which way the cat will jump. We shall await them with much interest.

A BRITISH VIEW ON MAKING CONCRETE

By H. V. Overfield, City Engineer's Office, Birmingham, England.

(Editor's Note: The following is from a paper by Mr. Overfield at a meeting in February, 1926, of the West Midland District of the Institution of Municipal and County Engineers.)

Concrete has now become an essential factor in the construction of roads which carry the heavy traffic of modern industrial cities. It is being increasingly employed in the foundations of main roads outside the urban areas, and it is probable that in the future concrete will prove the cheapest and must durable material for the cheapest of all road work in the development of building estates.

Although cement concrete has been used in such large quantities during the past century, neither the correct methods of manufacture nor its physical properties are widely enough known to place it in such a class of structural materials as steel. It is possible, however, to make concrete which will conform within close limits to given standards of quality. There is little doubt that an improvement of 100 per cent in strength could be effected without extra cost in much of the concrete made today.

Quality of Concrete

In every piece of concrete work certain strength and quality are required, and if the engineer can rely on the uniformity of the finished product, the concrete may be most economically employed.

The quality and uniformity can best be controlled and judged by compression tests on blocks made with the same materials and subjected to the same conditions as those in the work.

The strength of the cement used will be no guide to the strength of the concrete, neither can the compression strength of the concrete be guaranteed unless all the factors in the mixing and subsequent treatment are controlled.

It is not sufficient to specify that the concrete shall be made with certain materials in certain proportions. There may be great variations due to workmanship, while the use of an excess of water may lower the strength to only a fractional part of the value it should be with the same materials.

The compressive strength required for the work should be decided, and the materials may then be selected and proportioned to give the desired result.

Making the Concrete

The following factors are all of importance in making the concrete:

(1) The quality and proportion of cement.

(2) The quality and proportion of fine aggregate.

(3) The quality and proportion of coarse aggregate.

(4) The volume of water used in mixing.

(5) The methods of mixing and placing.

(6) The treatment after placing.

The proportion of cement is usually regarded as the determining factor in the strength of concrete, but the other five factors may be equally important, and greater loss of strength may occur through variations in any one than is generally possible by variation in the proportion of the cement, which is often the only factor carefully checked in practice.

(1) Cement.—It is not proposed to

discuss the quality of cement, which for the purposes of this discussion is assumed to be Portland cement complying with the British standard specification. In concretes with fixed relative volumes of fine and coarse aggregates the compressive strength increases directly, but not proportionately, as the cement to the total volume.

(2) and (3) *Aggregates.*—It has been determined by eminent investigators that the strongest concrete that can be made with given aggregates, other things being equal, is that in which these materials are combined so as to produce a mixture of maximum density—*i. e.*, with the least percentage of voids.

The type of aggregate—*i. e.*, whether granite, gravel, limestone or slag—is no guarantee of strength, but hardness, shearing strength and graduation of size of particles are of more importance.

Crushed gravel or stone does not make stronger concrete than round gravel. The percentage of voids in round material is always less than in crushed material from the same screens and the round material will therefore give a denser mixture.

Possibly green concrete will be the stronger when made with angular particles, but after a few weeks' set the adhesion of the mortar to clean, round gravel will be greater than the shearing strength of the stone, and the difference in strength disappears.

The crushing of gravel shatters the stone, and probably produces a much lower average shearing strength in the particles than in round gravel. Crushed stone is always covered with a layer of fine dust, which is not removed in mixing the concrete, and often prevents perfect adhesion of the mortar.

Concrete made with round gravel flows more readily into position than that made with angular aggregates, less water is needed to render it workable, and it makes a denser mixture, with less tamping.

Washed gravel can be obtained at less cost than crushed gravel or broken stone, and it is surprising that it is not more generally used.

The geological formation of this district indicates an inexhaustible supply of gravel, and there is no doubt that at no very distant date gravel will entirely supersede blast furnace slag in concrete work.

Fine Aggregate.—Sand for concrete work should be quite free from organic matter. A very small quantity of vegetable matter may entirely prevent the setting of the cement. It is on record that the collapse of a concrete building was due to the use of sand which contained only ½ per cent of vegetable impurities. The best test for detecting organic matter is to place a sample of the sand in a 3 per cent solution of sodium hydroxide, and after twenty-four hours the color of the liquid should not be darker than a light straw. This is a very simple and inexpensive test.

The presence of purely mineral matters, such as clay, in small quantities may not be detrimental in lean mortars, when this finely divided material may increase the density and water-tightness. In 1:2 and richer mortars the presence of clay would be detrimental. Very few natural sands in this district are free from impurities, and it is desirable to use washed sands. Coarse sands are the best for concrete work, and the nearer the mechanical analysis curve approaches a straight line the better. The term "sand," however, should be regarded as relative only as compared with the coarse aggregate; thus, a fine sand may be properly used with an aggregate containing fine material. The sand particles should range downwards in size from the smallest grade of the coarse aggregate.

A good specification should call for a siliceous sand, free from traces of organic matter, and not more than 30 per cent by weight passing a No. 50 sieve.

It is unnecessary to specify a sharp sand, as sands with rounded grains are equally good, and it is doubtful if natural sharp sand with angular grains is obtainable in this district.

Proportioning Concrete.—M. Feret, a French engineer, stated the theory for proportioning materials for concrete as follows:

"The problem of making the best concrete is thus reduced to the selection of a mixture of materials whose granulometric composition corresponds to the maximum of density, since, when this composition is known, absolute volumes of cement may be submitted for equal absolute volumes of fine sand, and vice versa, so as to vary the strength as desired while the density remains the same."

The proportions of the materials may be determined in several ways. The most usual method, in practice, is to make an arbitrary selection, the engineer deciding

from his practical experience what mixture is best suited for the particular work. Such arbitrary mixtures are made as follows:—

(*a*) The volume of the stone taken is twice the volume of the sand, as in 1:2:4 and 1:3:6 mixes.

(*b*) The volume of stone is taken as the volume of the cement plus twice the volume of the sand, as in 1:2:5 and 1:3:7 mixes.

The method of determining the proportions according to the measured voids in stone and sand is unreliable. The United States Bureau of Standards has proved by extensive tests that concrete made in such theoretical proportions is always weaker than 1:2:4 concrete and, with a few exceptions, is stronger than 1:3:6 mixture.

W. B. Fuller (Trans. Am. Soc. C. E., 1907) suggests that the materials should be combined in such proportions as will be represented by a mechanical analysis curve, which is a combination of part of an ellipse and a straight line. This he called the "maximum density curve," and developed methods of re combining the mechanical analysis curves of cement, sand and stone so that the proportions of a concrete mixture of maximum density could be deduced from the curve. Fuller claims to have used 1:3:7 concrete mixtures proportioned according to his curves for thin, water-tight wall construction where 1:2:4 concrete would ordinarily have been used.

From tests made by the U. S. Bureau of Standards it was deduced that "every aggregate has its own curve of maximum density, and no one curve can be used for combining dissimilar materials, even of the same type." It has further been laid down by this bureau that the correct proportions of coarse and fine aggregate for maximum strength can only be determined by trial.

The Bureau of Standards' very comprehensive tests showed that the addition of large stones to 1:2:4 concrete mixtures resulted in a concrete of higher strength, and suggest that great economies might be effected in large works by careful testing of proposed aggregates. Hence the maximum size of stone should be used which can be placed in the work. For concrete in roads 6 in. to 8 in. thick the stone should be graded up to 2 in. and 2 1-4 in.

The proportions employed in concrete foundations for paved roads appear to vary in practice between 1:6 and 1:9, and for the wearing coats of concrete roads between 1:2 and 1:5.

The author suggests that it is advisable to check the grading of aggregates by screening out samples and noting the percentage passing the various meshes.

The ideal mixture may be determined by making trial mixtures of concrete with measured volumes of cement, sand and various grades of stone. The mixture which produces the least volume of concrete is the densest, and therefore the strongest. Fuller's curve would be of assistance in indicating the probable proportions required.

Having determined the desired grading, crushed stone can be purchased in the correct proportions from quarry owners who separate each grade from the crushers. When using gravel from banks it will probably be necessary and economical to screen it once or twice and re-combine in different proportions to obtain the desired result.

(4) Volume of Mixing Water.—Water is required to cause cement to set, but an excess of mixing water chemically injures the cement and reduces the strength of the resulting mortar or concrete. From the tests of the U. S. Bureau of Standards it was proved that in practice the greatest variation in the strength of concrete is due to the varying quantities of water used in mixing.

It was found that concrete of maximum strength was produced by the use of 6 per cent of water for gravel and 8 per cent for limestone concretes. This is equivalent to 9 and 10 gallons of water in ½ cub. yd. batch of 1:2:4 concrete, the water being measured as a percentage of the total dry weight of cement and aggregate.

An excess of 3 per cent of water above that required for maximum strength caused a reduction of 50 per cent in the strength of limestone concrete, and more in the gravel concretes.

From Professor Duff Abrams' tables it is clear that to give equal strength a wet mixed concrete requires from two to two-and-a half times the volume of cement required in fairly dry or plaster mixture.

The class of work will determine the consistency or workability of the concrete required. In mass work fairly dry concrete may be used, but in reinforced structures it is necessary for the concrete to be wetter in order that it may be properly packed round the steel. This extra

workability is costly, owing to the extra cement required to produce concrete of a given strength. For economy the driest mixture that can be properly placed in the work should be used.

In practice the tendency is for concrete to be made much too wet. It is easier for the workmen to handle it in this state, and the production from machine mixers is much higher than that of dry concrete.

It is useless to specify that a given volume of water shall be used in mixing, as the amount of water in the sand and aggregate will be variable.

The required consistency or workability of the mixed concrete should be specified, and at present the only reliable measure of this property is the slump test. When carried out strictly in accordance with the conditions laid down by the Joint Committee of the American Concrete Institute this test is very sensitive to slight changes in the proportion of water.

Concrete for use in road work should be of a plastic consistency with a slump of ½ in. to 1 in.

The writer has found that in practice it is only necessary to make a few slump tests in order to demonstrate to workmen the required consistency of the concrete, and they are then able to produce very uniform mixtures.

(5) Mixing and Placing Concrete.—Good concrete may be made either by hand or machinery, but in actual work, mixing for not less than one minute in a rotary mixer will produce stronger and more uniform concrete than the average hand-mixing process.

An improvement to most concrete mixers would be a device for automatically delivering the requisite volume of water to each batch, so that this important duty need not be left to the judgment of a laborer.

The writer has found that rotary machines do not readily discharge the entire batch of concrete of fairly dry consistency, and that much time is lost in clearing the drums. It is probable that mixers of the paddle type, as used for bituminous materials, might give better results.

When the concrete is being placed in position, it should be rammed sufficiently to expel all air bubbles. In road slabs, where the thickness is small, particular care should be taken that the tamping is not overdone, as this is liable to bring the mortar to the surface and leave bare stones in the bottom.

All the operations of mixing, placing and tamping concrete must be completed before the cement takes its initial set.

DAY LABOR ON MICHIGAN HIGHWAY CONSTRUCTION

(From the Bulletin of Ohio Contractor's Association)

We have noted in the bulletin from time to time the fact that the Michigan State Highway Department has been doing the greater part of its construction work by direct labor. In addressing the American Association of State Highway Officials at their recent Detroit convention, Governor Groesbeck of Michigan declared that it was an impossibility to build by contract a highway which will hold up and serve the public.

The lid has not yet been taken off in Michigan, but it has been tilted enough to show what Mr. Groesbeck's direct labor methods are costing the tax-payers of Michigan. The first shock came when the state disclosed the cost of building a section of the Grand River road in Oakland county. This work was estimated to cost about $31,000.00 per mile. When the Michigan Highway Department recently billed Oakland county for its share of the cost, the Oakland county officials were greatly surprised to discover that the road had cost more than $52,000.00 per mile, or $21,000.00 per mile more than the original state estimate.

This was rather disconcerting, but it remained for Genesee county to get the real surprise. The state had constructed several miles of twenty foot concrete on the Dixie highway in Genesee county. This was a resurfacing job and the original state estimate was $29,208.64 per mile. This was a resurfacing job, the old eighteen foot pavement not being disturbed and a twenty foot concrete slab, thickness not stated, being super-imposed on top of the old pavement and grade. When Genesee county received its bill for the county's share of the cost it developed that this twenty foot concrete slab had cost $74,980.56 per mile.

The citizens of Michigan have so far been unable to obtain any information concerning the cost of Michigan state highway construction other than on those two projects. The Michigan state highway department had a state appropriation of over $22,000,000 last year, but now faces a large deficit including a shortage of $1,500,000 in the sinking fund. Gover-

nor Groesbeck has called the Michigan legislature in special session and is asking them for additional appropriations for the highway department. The disclosure of the cost figures in Oakland and Genesee counties has stirred up a pretty mess and many members of the legislature are demanding an accounting from the governor as to what became of the $22,000,000 appropriated a year ago.

Governor Groesbeck was strong enough last week to defeat immediate consideration by the legislature of a resolution demanding an accounting from him as to highway expenditures. One of the principal distinguishing characteristics of force account or direct labor on public works is its tenacity to life. A state highway department which is disposed to build up a large force account organization, and which is permitted to do so, can place so many politicians and their henchmen in political jobs that when any effort is made to get the real facts or to cut down the size of the political organization, tremendous pressure can be and is brought on the members of the legislature to keep on the lid and to save the jobs. The Michigan legislature which began its special session last week resumes its labors this week and the outcome will be watched with great interest.

WHY AMERICAN ENGINEERING COUNCIL?

By President Dexter S. Kimball

(Remarks at Dinner of American Engineering Council, Chevy Chase, Md., Jan. 15, 1926)

Civilization at best is a complicated matter. In all times and at all places wherever men have congregated with any extended use of division of labor, the problem of insuring justice and a square deal for all has proven to be a difficult and baffling task. Of the many basic conceptions for accomplishing this result I shall speak of only two.

The first method and one which was quite common among our remote ancestors was to settle these matters by edict, some ruler in whom wisdom was supposed to reside acting as judge and arbiter. Such methods are well illustrated in the laws of Hammurabi which were promulgated over 4000 years ago, the code being one of the earliest recorded documents of this kind. These laws are dogmatic in character and are based upon the general principle of "eye for eye and tooth for tooth." In a simple handicraft civilization, and under a wise ruler, such methods possibly may suffice, though the ultimate success of the effort to limit natural economic laws by edict, as is done in the Code of Hammurabi, may be seriously questioned.

The second method of settling the difficulties of civilization to which I shall refer is by an appeal to experience and precedent as is done so largely in our present legal system. So far as the civilization to which we are the heirs is concerned this method found its first great expression in the Justinian Code promulgated in the sixth century and partly because of which we still live beneath the shadow of the Roman eagle. The logic of this method is sound since it is reasonable to assume that similar conditions necessitate similar treatment and if a certain procedure is found to be sound and successful in one case it is reasonable to assume that it is applicable to other cases where the conditions are the same. In a civilization where the basic conditions of living have become stabilized, as occurred in China, an appeal to precedent representing a vast body of accumulated experience might be amply sufficient. And even in a civilization where the conditions of existence change at moderate speed it might be possible for law makers to keep reasonably abreast of progress and settle the affairs of the nation with considerable fairness.

During the last seventy-five years the basis of civilization in this country and a few others has been changed in a greater degree than in all the preceding centuries of man's existence on this planet. Furthermore, the rate at which this change has been brought about vastly exceeds anything of which we have record and there is no sign, as yet, that these rapid changes will not continue for some time to come. These basic industrial changes have brought about marked changes in our social and political fabric and have created conditions with which we have had little or no previous experience. The problems incident to these new conditions often cannot be solved by an appeal to precedent, much less to edict. As a consequence we often flounder about hopelessly in our law-making efforts simply because we do not understand the complex causes of these results.

Now these basic changes have been brought about largely through the work of the scientist and the engineer and the

latter is peculiarly well informed as to many of the basic causes that have produced such troublesome results. The engineer has performed his truly marvelous work by using the old though still little known methods that we speak of as scientific that he has acquired from the mathematician, the chemist and the physicist, and he believes, with very good reason, that the same logical methods that have built up modern civilization will be equally efficacious in curing its ills and perpetuating it. And it should be noted that in the application of the scientific method edict has no place and precedent may be trusted only when it has been proven to be sound under the most exhaustive tests. This is not peculiar to engineering as a brief consideration of the field of medicine will reveal. And those who have built up modern medicine using the same scientific methods of attack have made a contribution to modern civilization second to no other group of scientific workers.

When, however, the scientist or the engineer is brought into contact with lawmakers and others who are trying to adjust the social and political machinery of our country and particularly when he is called upon to co-operate with such others it is often to him a distressing experience to find them wholly ignorant of logical scientific methods of attacking problems, but instead finds them searching for precedents where none exist, worse still using precedent that does not apply or possibly trying to settle the matter by compromise on the ground of expediency alone.

The American Engineering Council is, therefore, an effort to place the knowledge and experience of the engineer at the service of the city, the state, and the nation for the solution of such social and political problems as may properly fall within his knowledge and experience. And in so doing we have no illusions as to the limitations of this knowledge and experience. We are only too well aware that the solution of these problems will require the best efforts of many men of many minds. But we do affirm that if the engineers of this country will attack many of these national problems, especially those that have their origin in the complexity of industry, with the same energy and the same methods that have been used so successfully to create modern industry they can make a great contribution to this commonwealth. They can do much to make this world a happier one, for it will be a more intelligent world where many of these difficult industrial, social and political problems, that we are now trying to solve by edict or inapplicable precedent, will have been brought into scientific analysis.

CLOSED SPECIFICATIONS

A Farce, Otherwise Known as "The Inspired Material Salesman vs. Open Specifications"

PROLOGUE

The average citizen is at heart an optimist. It matters not a great deal whether he earns his livelihood in one of the professions (learned or otherwise); in the general conduct of business; or by the sweat of his brow induced by physical effort in the shop or in the field. The farmer is included in the list despite the fact that we of the city sometimes accuse him of being anything but an optimist. If, then, we may be considered as optimists, we are, indeed, progressing—we are looking and working for better times—better living conditions—more comforts in the future. Such a condition means that our collective mind is constantly acquiring education; we are either becoming more intelligent beings or better educated fools.

While inclined strongly to the opinion that our knowledge is increasing and our common sense and good judgment broadening out in consequence thereof, yet occasionally incidents do occur that are strongly indicative of a throwback to at least the "palmy days" of the gold brick artists.

Modern chemistry has so often demonstrated its ability to equal and in some cases to improve upon nature—in fact to even create things that never existed in nature, that it would seem ridiculous for us to build walls around any product, more or less natural though it might be, so as to protect it against competition of man-made products of identically the same character except that the manufactured article is apt to be much more refined and pure and is surely the equal in quality of the natural product. By the same token it would be just as foolish to set up restrictions against the use of a natural product of proven merit. Yet that is exactly what municipal officials do when they restrict competition in paving bids by means of closed specifications. This vicious instrument is not as common as it once was, but it still bobs up

now and then. Now let us listen in upon one method that may be used by the inspired salesman to insure freedom from competition for his product. Little cares he for the spirit of fairness to the taxpayer that prompted laws governing public contracts.

ACT I

(Honest John Wippleby, Mayor of Whipplevale, is seen busily engaged in opening his "cash" grocery for the day's business, i. e., he has just swept out the store room and lowered the awnings against the bright morning sun—now he is skimming the flies from the dillpickle jar and is whistling merrily at the task. A robust, suitably attired male individual strides through the doorway and the following conversation takes place):

Robust Gentleman—"Good morning, Mr. Whiffleday, my name is Henry B. Slick; the boys at the office call me 'B. S.' for short. I understand that you are going to pave Main Drag from the R. R. tracks to the Fair Grounds, and that there has been some talk of including Bungalow Ave. Now, Mr. Whittlegay, you are a business man and as a man of intelligence and as Mayor of this beautiful city, you are interested in the best kind of pavement, and properly so. Mr. Whippley, I represent the Arabian Toothpick Paving Co.—we make the best toothpicks ever used to pave a street; in fact, would you believe it?—the streets of Sodom were paved in 7000 B. C. with this identical material, and some of them are still in use today."

Mr. Whippleby: (moving his specs farther down on his nose so as to better view Mr. Slick) "Well, we did allow we ought to pave Main Drag—you see, they paved First Street over at Punkville last summer—they used mothball concrete and we kind o' thought we would use the same material"——

Mr. H. B. Slick (with a very engaging smile): "Pardon me for interrupting, but surely you don't want to lay any mothball concrete—not with your climate here in Whipplevale. Now that pavement may do all right over in Punkville, but not here. Why? In hot weather you can smell those mothballs something awful. Now, the only pavement for you is Toothpick Fabric, and only one toothpick at that—use our Arabian Toothpicks and have no bad odors or regrets of any kind. Man alive, The Lord Almighty, Himself, gave Arabian Toothpicks to the world for paving streets, all other brands of toothpicks are artificial, by-products, and, therefore, can't compare with ours. Our toothpick mines are located in the Great Arabian Desert. At great cost we laboriously mine them and sort them out according to size so that you are absolutely assured that you will get nothing less than pure unadulterated Arabian toothpicks, placed by nature in our mines and weathered by natural processes, mined and marketed exclusively by us. Don't take a chance on toothpicks made by man, not even those made in the most up-to-date mill in the country, from selected timber—they are only by-products made from short pieces of timber that can't be used for anything else. In fact, I'm telling you confidentially, they are the residue from the manufacture of Japanese matches. Our toothpicks don't form slivers like the others."

Mayor Whippleby (the wise old fox, accustomed to buy groceries from Bill Smith of the A. B. C. Grocery Co.): "You say yours are the best, but don't they cost a lot more than those made right here in our own country?"

B. S. (hoping the old boy wouldn't ask that question, but ready for it, nevertheless): "You said it—why shouldn't our product sell for a little more money—it is the best on the market, isn't it? Take prunes, for instance, now I dont' presume to know anything about the grocery business, but you do—you're an expert in that line; been in it all your life, haven't you? I'll bet you have to pay more for imported prunes than you do for the domestic grade?"

Mayor W. (beginning to see the light): "Well, that's true—yes we do."

B. S. (driving the argument home): "Now, I'm an expert in the paving game; I know this business just like you know the grocery business. True, our product will cost you a little more than those fellows over in Punkville paid for their mothball concrete, but look what you are getting—not merely a Toothpick Fabric pavement, but a genuine Arabian Toothpick Fabric—the best of all the types known to the engineering profession, made of the best toothpicks on earth, something you will be proud of, and you, as Mayor of this fine city, can't afford to pass up such an opportunity to build a monument to yourself, right here in your own home town."

The Mayor (almost ready to bite): "Well, maybe you're right, but I don't know what the other boys on the Coun-

cil might say, and then, we've got an engineer, old Jeb Afterthought's boy Willie. Willie's a smart lad—went over to the State University and took up engineering—I guess by rights we ought to see what he has to say about it."

H. B. Slick (thinking fast now): "Now, see here, Mr. Mayor. You're too good a businessman and too smart to let any young chap like this boy, whom you've known since he was in short pants, tell you what you ought to do as Mayor of this town. Now, I've been in this paving business all my life, laid millions of yards of it—and I tell you we've got the best there is. Why you're lucky I came here—(only by accident too, that I stopped here). Just think, you might have gone ahead and let this boy convince you that Punkville's pavement was good enough forWhipplevale. Just think of that! Now, I've got an idea, you call up all the other Councilmen and meet me up at the Whipple House at noon and we'll have dinner, and talk this thing over—and, oh, yes! (leans over and whispers to the old man, who glows appreciatively).

His Honor: "Well, I haven't had a nip since a year come next October. All right, we'll be there."

ACT II

And they were—and they did.

ACT III

Omitted, being left to the imagination of the readers.

And now, having followed the above, the reader will have guessed the outcome of the luncheon party. Yes—they decided upon a special Council meeting that evening. The engineer was notified to be present, although, true enough, he might have employed his time more profitably at home listening in on Q. E. D. He didn't have much chance to express himself but did get in a question something about wondering whether Arabian Toothpicks were pure wood; to which Mr. Slick replied "No, indeed, our product is much better than the pure fibre—why, don't you know, the original sap is still in everyone of our toothpicks—crystalized by the processes of nature's own chemical laboratory—thus adding untold merit to our material?" Thereafter, the meeting rapidly came to a close, with final instructions to the engineer to prepare plans and specifications for paving with Arabian Toothpick Fabric. And, as a last and crowning act of beneficence, Mr. Henry B. Slick handed Mr. Engineer a neatly printed specification covering the subject in ample English. And, so, Whipplevale after due course awarded a contract for the paving work at double its fair value.

There are at least a dozen or two versions of the above little farce that, no doubt, have suggested themselves to the reader. True, there is a certain amount of humor attached to the situation, chiefly because of its utter ridiculousness. But—can you think of a single version of the above foolishness that is not in reality a tragedy instead of a farce?

(Contributed by Hugh W. Skidmore, of Chicago Paving Laboratory, Inc., 536 Lake Shore Drive, Chicago, Illinois.)

LOCATING RURAL HIGHWAYS

By Col. W. W. Crosby, Location Engineer, Pennsylvania Department of Highways, Harrisburg, Pa.

(Paper before 1926 meeting of American Road Builders Association.)

Until recently Highway Engineering has been engaged mainly in superficialities. The surfacing of roads and streets, with the details that entered the considerations of the construction, reconstruction, and maintenance of modern surfaces on the old routes or layouts has been the main occupation of highway authorities generally. Road-building has overshadowed highway engineering.

Is it now not time to lift our noses from our grindstones and look ahead questioningly, with a view to conclusions as to whether or not the highway locations that are now being superficially improved with modern durable roadways will be any more free from criticism well within the life of the surfacings being provided than are the old alignments of yesterday?

And is it not up to the Highway Engineer to lead rather than to be driven by the public in this matter?

Highway Location may be of two sorts: (a) Actual location where none now exists, or Relocation and Line Revision partly over old rights of way and partly over new; and

(b) Selection of existing routes first, with then the operation of "a" above.

So far Selective Location (b) has been mainly political. A few instances exist where engineering advice entered, but it seems safe to state there is none where it has been given proper opportunity or effect. We are just beginning to be aware

of the fundamental importance to the state and to the nation of advanced engineering conceptions in this matter of highway location by selection, and there is great need for preparation by highway engineers to fulfill their responsibilities in this connection.

This preparation can probably best be made through studies and practice under (a), which for convenience hereafter may simply be considered in the light now of relocation and line revision in cases of existing routes of public travel.

All are familiar with the defects of old alignments, such as abrupt turns, excessive grades over hills, or detoured roadways around fields valuable for crops, and of the desire or need for remedying to the ends of convenience, economy and safety for traffic, such defects by relocations of the highway. These same problems magnified take the aspect of more direct and better graded routes, by passes of congested centers and even of a better correlation of highway transport facilities with those of rail and water.

A successful approach to any problem of highway relocation or line revision involves a comprehension of the traffic changes that have occurred and a reasonable anticipation of further developments on that line. But beyond this recognition of that subject this paper will not dilate on these matters further than to point out here, once and for all, one fact. It is this: highway location must now and hereafter recognize the existence of a sort of fourth dimension in its problems. That fourth dimension is speed (or time), which is to be added to the other dimensions of length, width (or breadth), and thickness (or profile, i. e. grades).

When the problems under discussion shall have been solved in the four dimensions noted—or even during its solution —the economic factor is reached, and may also involve a social factor more or less resembling a political one sometimes.

Frequently the highway engineer is not in a position to consider the question beyond the purely economic side, though he may be and should strive to be prepared to do so. But usually he must hold some sound ideas up to and including the economics of location questions, and he may even need to have a proper comprehension of sociology.

There is at present need among the profession, and even greater want outside of it, for sound conclusions on a number of points directly affecting the solution of location problems—even in line revisions—and concerning such primaries as—

The costs of length, which are economic;

The effects of grades, which are both physical and economic;

The effects of curves, which are physical;

The property of speeds, which are both physical and economic; all in connection with modern traffic on the highways and the developments of this traffic reasonably to be expected and to be provided for within say the next score of years or the expected life of the roadways now being provided by either bond issues or taxation.

Conclusions on these points as well as on many other minor principles or other equally important ones do not seem to be as yet sufficiently widespread or developed to meet the needs. There is a pressing demand for them and it is to be hoped that some may soon be reached by this avenue for approach through this meeting and this powerful Association.

Some states have recognized the importance of some of the problems of highway location and perhaps Pennsylvania has advanced farther directly in this matter than any other. In illustration, therefore, of what has been said and in exposition of the Pennsylvania consideration of location problems, it may now be best to cite a specific case that came up in 1925 in that State.

State Highway Route 153 was established by the Legislature (and later officially selected as a primary route of the system) to begin at Philadelphia City near Chestnut Hill, and

"Thence running by way of Fort Washington, Spring House, Montgomeryville and Colmar to a point on the dividing line between Montgomery and Bucks Counties; thence to Line Lexington, Sellersville, Rockhill and Quakertown, to a point on the dividing line between Bucks and Lebanon Counties; thence by way of Coopersburg to a point on the boundary line of the City of Allentown, Lebanon County."

The old road identifiable by the above description has been marked on the published maps of the Department as a primary state highway route.

It has been held by the legal authorities of the state that the Highway Department must improve or maintain the route between Philadelphia and Allentown as

identified by the Legislative description, though the improved roadway may vary from the original or present public road or right of way between these points, *provided that*, if the new highway shall be relocated so as to by-pass the intermediate villages or boroughs named, a proper connection or spur shall be provided by the State between each of these settlements and any relocation for the state highway.

Now in this case it appears that previously a modern paved roadway has been provided along the right of way of the old road from the point of beginning of the above Legislative description (the Philadelphia City line at Chestnut Hill) for seven miles to Spring House on route to Allentown (forty-one miles from Philadelphia) and that this roadway is satisfactory to the present requirements on it. From Spring House to Quakertown (twenty miles) the present roadway is in such condition as to be reasonably sufficient for the present and no improvement is contemplated by the State for this section at present. The existing roadway of the established route from Quakertown to Center Valley (seven or eight miles) is in such condition that its resurfacing must be done by the State at once. From Center Valley to Allentown (six miles) the existing road, having been recently improved, may be taken as outside the present consideration.

The question that first arises, therefore, is as to just what location or alignment shall now be contemplated for the section of new roadway now to be provided on this route for the part between Quakertown and Center Valley.

Philadelphia, the third city in population of the United States, of course is a large center of production and consumption. Allentown is a growing center, and, with Bethlehem less than five miles away, forms an important region for production and consumption. The distance between the two regions (Philadelphia and Allentown-Bethlehem) is well within the radius of efficient motor trucking operations over a direct connection by improved public highway. Such operations demand several provisions to be made properly: directness; avoidance of unnecessary length or excessive curvative and grades; sufficient widths; avoidance of local congestion and of danger; together with proper regard for local convenience and use of this route which for the present must be considered as a general purpose highway.

It, therefore, seems necessary before the propriety of the present location of a section of the entire route can be determined, first to examine the route as a whole.

The Transportation Surveys (of 1923 and 1924) show the following figures as regards the traffic use of this route—

TRAFFIC COUNTS—1923

Location on Route	Av. Sunday (total)	Av. Daily (total)	Av. Daily Trucks
Nine Separate Stations Average	3230	1540	275

TRAFFIC COUNTS—1924

Location on Route	Classification	Summer	Winter	Av. Daily Traffic
Three Separate Stations Average	Trucks	164	129	146
	Passenger Cars	1542	823	1183
Total		1706	952	1329

It is apparent that the route may be regarded (relatively at least) as a heavily traveled one on which future traffic is to be much more severe and numerous within the life of the more durable roadway now proposed to be built. The improvement of the roadway will accentuate these conclusions.

The present alignment of the route between the termini—and in some cases between the intermediate points mentioned in the Act—is somewhat indirect and thus excessively long; the grades on the present alignment are more severe than are now or likely to be satisfactory; and congestion and dangerous situations for all traffic exist at numerous places along the present alignment. Discomfort, dissatisfaction and inconvenience also are suffered by the residents along the present roadway from the conflict of interest between the through or foreign traffic and the local enjoyment of the roadway.

Reference now to the map showing the route, its controls, and the topography reveals the following:

An "Air-Line" from the "center of gravity" of Allentown and Bethlehem to Philadelphia passes through or close to Center Valley. This latter point is in a gap in the hills through which the route must come from the south into Allen-

town and Bethlehem, and also forms a convenient point for diverging from the air line by T's or branches to the individual centers of both these towns, which are about five miles apart and each practically the same distance from Center Valley.

From Center Valley southerly to Philadelphia the air line would pass east of the present location in the village of Coopersburg; through Quakertown; a little west of Rock Hill and of Sellersville; be nearly coincident with the present location at the Bucks-Montgomery County line; and then lie to the west of Line Lexington and of the present route through Montgomeryville, Colmar, Springhouse and Fort Washington to coincide again and at the Philadelphia City line.

It has been noted that a roadway satisfactory for the present needs exists south of Quakertown. The net problem now is, therefore, the location above Quakertown to Center Valley, both these points being coincident on the present route and the air line. Whatever the future may hold for relocation below Quakertown (to Philadelphia) evidently no consideration of that section need now be included with that of the section from Quakertown to Center Valley.

With the limits so arrived at for study as to improvement now with a durable type surface (i. e. between Beaver Run, south of Quakertown, and Center Valley), the air line is 6.85 miles or a mile less than the length of the present road. This air line appears impracticable, as it cuts Quakertown and Coopersburg diagonally, which would cause excessive property damage and also introduce difficult and dangerous traffic conditions due to passing through main parts of the boroughs. It further introduces two railroad crossings with consequent problems and complications; does not fit the topography to advantage; creates a duplication of nearly parallel roads in certain narrow sections; does not serve rural interests to advantage, beside causing excessive damages.

A study of the topographic maps available and covering a section between Rich Hill (just south of Quakertown) and Center Valley enables a suggestion to be made for a relocation on an approximate air line between these points that will offer many advantages, along the lines indicated before as desirable, such as greater directness, shorter lengths, better grades, avoidance of congestion, and other dangers to traffic. The relocation so suggested will also bring this section of the route very closely in alignment with the most direct route needed between the termini of Philadelphia and the Allentown-Bethlehem region, so that its improvement now would seem to form a real step toward what may be considered as an ultimately desirable establishment, though for some years to come the rest of the establishment may not be completed and the present character of the highway as a general purpose one, but not a special industrial highway, may be retained and that function of it served.

A preliminary field survey of the suggestion developed from the maps was, therefore, authorized and was made by the district engineer's forces. The Location Engineer, from the facts thus developed, then recommended to the Engineering Executive that the relocation be approved for reasons summarized as follows:

"The relocation (the approximate air line) shown on the attached print is in conformity with the requirements of the existing Legislative Act establishing this route.

"Scenic and similar considerations on the proposed relocation are equivalent to if not better than such features along the present route location.

"The proposed location will avoid, for through traffic, one grade and two half-grade crossings with the Lehigh Valley Transit Company (Liberty Bell Route) which exist on the present location of the route. However, the relocation will require the creation of a new grade crossing with the Lehigh Valley Transit Company at a point to the northwest of Quakertown Borough. The present route, through the latter place, parallels the trolley tracks and consequently there is created a rather undesirable congested traffic condition along the present narrow built-up street (35 ft. between curbs). The relocation avoids this unsatisfactory feature entirely.

The character of the country traversed by the relocation is mostly farming land. Between the termini of the two locations there are thirteen houses and two schools along the relocation, and 143 houses, 5 churches and 2 schools along the present route.. In addition, either of the locations serves Coopersburg (89 houses) and Quakertown (97 houses).

"The length of the present route is 52,712 ft. or 5,012 ft. more than the length of the relocation (47,700 ft.) which is an

appreciable saving in favor of the latter on this important primary route. It will further be noted that the relocation as proposed conforms very closely to the ideal air line location between Center Valley and Rich Hill.

"The maximum grade on the present road is 7.94% which extends for a continuous length of 1,025 ft., whereas on the relocation the maximum grade will not exceed 8% for a length of 600 ft.

"The proposed line, in Quakertown Borough, will avoid an exceptionally sharp curve in a narrow and built-up section. This undesirable and dangerous condition that exists along the present route cannot be sufficiently modified to be satisfactory without involving excessive property damages. The alignment along the relocation is a vast improvement over that along the present route, the maximum degree of curvature being one nine-degree and thirty-minute curve on the former as against a maximum of three fourteen-degree curves on the latter (exclusive of the present sixty-degree curve in Quakertown Borough).

It is estimated that the cost of construction on the present location would be $424,385 or $16,241 more than the estimated construction costs via the proposed relocation ($408,144).

"The present daily traffic is reported as 1,346 passenger cars and 183 trucks. The probable future daily traffic is estimated as 2,700 passenger cars and 400 trucks. Predicated on the latter traffic figures the economic formulae of this Department show the following annual operation costs:

	Present Route	Proposed Location
Passenger cars	$ 941,654	$ 852,026
Trucks	531,195	476,552
	$1,472,849	$1,328,578

or an annual saving of $144,271 in favor of the relocation.

"The value of the land traversed by the relocation is about $125 to $200 per acre for farming land and about $50 per acre for marsh land, I am informed. The total land damages involved in obtaining the necessary lands for ultimate right of way purposes on this relocation would amount to approximately $15,350. In addition, the moving back of buildings to obtain a hundred foot right of way with the incidental minor line revisions is about $150 an acre, involving total land damages of $12,300. Property damages on the old location, because of the built-up conditions now prevalent, would amount to about $285,000 in order to obtain the prescribed ultimate right of way width. Ultimate damages, therefore, would be $270,550 more along the present route location than via the relocation.

"No abnormal maintenance conditions nor unusual construction difficulties would be encountered along either of the locations considered."

Conclusions

In conclusion it may be said:

Proper Location will do much now to relieve promptly traffic dangers existing or imminent. Often we can "Build the Safety into the Location."

The advances made in road building and in highway engineering during the past thirty years, and particularly in the last ten years, warrant hope for even greater advances in the near future. But they also impose on those now active in the work responsibility for recognition of past errors; of advances to date; of present accomplishments, and for reasonable foresight as to future developments.

Mistakes today are not as excusable as they have been.

There are a number of lines along which further advance is needed in Highway Engineering such as, for instance, the relative effects of length, widths, grades, and speeds in the light of economics and social welfare as well as in that of mechanics or finance. And, Highway Location must be seriously considered as related to railroad, waterway, and even airway transportation and routes.

There is this final point the writer now wishes to make at this opportunity—

Mass production of roadway surfacing tends to interfere with the proper study of location problems. If the latter are to be properly solved, they must be contemplated and their solution begun well in advance of the annual construction program.

HOW TURKEY CONTROLS AUTO SPEEDING

L. A. Scipio, Dean of Engineering, Roberts College, Constantinople, Turkey, is a graduate of Purdue University, class of 1908. In a recent article in the "Purdue Alumnus" he describes certain Oriental customs. His description of the method used to check motor vehicle speeding follows:

Automobiles have become quite numerous, the greater number of which are American made. New speed regulations have gone into force during the last three weeks, making seven miles the limit within the city. Traffic police are stationed at various places where the temptation to exceed the limit is greatest and these are armed with a board some five feet long with 4-inch spikes. When a car is seen coming at rather lively pace the board is quickly placed in the road directly in front of the car. The law states that the board must be placed exactly four meters in front of the moving car. If the chauffeur succeeds in stopping before he comes to the nails, he is regarded as not to have been exceeding the limit. Also, his brakes are considered to be in good condition. More than one hundred chauffeurs have been arrested for exceeding the limit, many have been fined fifty pounds (about $240) and quite a number have been given from twenty-five to fifty lashes in addition. These measures may seem a little drastic to the average American driver but no one can deny that they are effective.

CAUSE AND PREVENTION OF EFFLORESCENCE

Efflorescence is one of the annoying minor troubles in construction. It may occur on any kind of masonry, and while not serious, it does detract from the good appearance of a building. The cause of efflorescence, or as it is sometimes called, "fuzz" or "bloom," is often misunderstood. Sometimes the blame is placed on lime, for dry lime and the crystals of efflorescence look somewhat alike, both being white and powdery. However, the similarity stops there, for the two materials are entirely different, says R. P. Brown, writing in the "American Architect".

Chemical analysis of sample of efflorescence shows that this white "bloom" is composed of salt crystals. The salts which cause the trouble are all soluble in water, and are usually chlorides or sulphates. Sodium, magnesium or calcium sulphates, commonly known as Epsom salts or Glaubers salts, are the chief offenders. The chlorides that usually give trouble are sodium chloride (table salt) and calcium chloride, both frequently used in cold weather to lower the freezing point of water.

These trouble-making salts may come from various sources. Dirty sand may carry them, or a mineral water may have been used for mixing the mortar or wetting down the masonry materials. However, if washed sand and pure water are used with lime and portland cement for the mortar, the danger is usually eliminated. Even if the salts are present in the materials, there is little danger of efflorescence if the wall is protected during construction.

Efflorescence is an indication of excess water within the wall. This free water must come to an exposed surface to evaporate and there it will deposit any material which it has in solution. Thus if it has dissolved these soluble salts it will deposit them as efflorescence on the surface. If the wall is porous it may soak up considerable moisture during wet weather, or a leak due to defective flashing or faulty plumbing may let water into the wall. In either case the excess water will dissolve the salts out of the masonry, and leave them on the surface as the water evaporates.

When first deposited efflorescence can be washed off with water, either by a hose or brush. When efflorescence is heavy or when it has dried, it may be necessary to add a little commercial muriatic acid to the water, making about a 10 percent solution. When acid is used, the wall should be thoroughly washed down with fresh water afterwards.

Simple tests will disclose the presence of chlorides or sulphates which have caused the efflorescence. For chlorides, dissolve some of the "bloom" in distilled water. Add to this solution a drop or two of ordinary silver nitrate solution. If chlorides are present the solution will immediately become cloudy, and any great quantity will produce a considerable soft white precipitate which will be deposited in the bottom of the test tube or beaker. When exposed to the light this precipitate will turn dark.

For sulphates, dissolve a sample of the fuzz in boiling distilled water to which a few drops of hydrochloric (muriatic) acid have been added. This solution should be strong enough to turn blue litmus paper red. While the solution is still boiling add some 10 percent barium chloride solution. If sulphates are present in appreciable quantities a heavy cloud will at once appear and drop to the bottom. The amount of sulphate present is roughly indicated by how rapidly the cloud forms and how much pre-

cipitate is deposited. The litmus paper and barium chloride solution may be purchased at any drug store.

It is a simple matter to test the sand and water to be used, and if desired, the other materials also. There may be a very small amount of calcium sulphate present in the lime (due to sulphur in the coal used), and the test will locate even a trace. The amount actually present in good commercial limes, as determined by many careful chemical analyses, is small and will not cause efflorescence.

If the nature of a structure requires that its walls should be free of this deposit of salt, entire safety may be secured by testing the materials beforehand by soaking them in water and then testing the water after a time to see if any sulphates or chlorides are present. But it should be noted that efflorescence occurs only when a wall is kept very wet for some time after construction, and that there is little danger of its appearance in dry weather.

HIGHWAY FINANCE—FEDERAL, STATE AND LOCAL

By Thomas H. MacDonald, Chief, U. S. Bureau of Public Roads, Washington, D. C.

(Address at 1926 meeting of American Roadbuilders' Association.)

Highway finance in all its phases would not be exhausted as a topic for exposition if all the sessions of this association were limited to this one subject.

There is great progress in the professional field of highway engineering. There is fully comparable progress in the field of power and mechanical equipment and its utilization for construction and maintenance of highways.

The growth in the production of materials is apparently keeping pace. The developments in the field of highway transportation continually reach beyond our expectations. First, we were astonished by the increase annually in the number of automobiles brought into use. Next, the motor truck appeared in numbers beyond our belief. Now we are just awakening to the spectacular and widespread ramifications of motor bus services. Already in the common carrier field the motor truck is insignificant as compared with the motor bus.

In this great nation-wide panorama of highways and highway transport, the laggard in the procession of progress is highway administration and the very core of highway administration is this matter of highway finance.

Highway administration as here used is not to be confused with the administration of state highway departments or their handling of public roads. Much progress is being made in methods and economy of production by a majority of these departments. For these same results generous credit should also be given to the material and equipment industries and to the road contractors and their organizations.

Highway administration in the national sense, is the business of organizing into system, under responsible authority, 3,000,000 miles of public roads and improving, maintaining and policing them for the safe and economical operation of 20,000,000 motor vehicles—and one thing more, financing these operations on a profit earning basis. This is a statement of the partial problem. The whole includes many thousand miles of urban streets. A big business enterprise conducted by the public for itself and the foundation for the whole structure is the financing.

The highway expenditures for a nation must be considered in their relation to all the factors constituting a nation's economy. For several years the United States has been operating on an annual program of approximately one billion dollars for rural highways. This is a large program. It is large for a nation liberally endowed with natural resources and with vast accumulated wealth. The dimensions are so large, their continuation undiminished is the best evidence of general public support. But this alone is not sufficient to give confidence. There are and should be questions. Can a program of such proportions stand the test of cold analysis? Can it justify itself in a critical determination of its relative importance in the whole list of desirable public activities? Are its dimensions in harmony with the service needs of the traffic? These questions are timely and sane. They should be answered. But they only concern themselves with the total money outgo. There are other questions equally as important. For example, are the taxes falling too heavily on some classes of property and on certain governmental entities? This and many similar questions relate to the other side, that is, the incomes or receipts tot support the program. Perhaps, most important of all are these questions: What progress is being made and what will be the trend

of the total annual highway bill in the future? Will it be up or down?

These aspects of the subject of highway finance appear to be the most important since there is constant need for legislative and executive determination of highway policies—financial, engineering and administrative, and unless more progress is made soon than resulted during the past year, the business cannot succeed.

The financial program cannot stand alone, and while it may be said that in these, the earlier years of the great development of motor transport, the financial policy determines the engineering policies and program of road construction and maintenance, in the course of a period of years the present engineering policies will determine what the financial program must be. The two are intimately interwoven, and of the two the economic engineering aspect will in the end govern. It will govern because there are certain laws which can never be defeated over a period of time. These are economic laws, and the most important one bearing upon highway finance is the law of compensation for waste. All waste must be paid for in one form or another. This is inevitable and the waste in highway transport resulting from the lack of adequate highways will cost the nation more than to provide them. This truth I have stated over and over in many forms, and the results of transport surveys and economic studies as they become available in larger measure are supporting the certainty of the workings of this principle. It is no longer necessary to hazard guesses. While it is not yet possible to present all the facts which have a bearing on the subject of a nation's highway finance, in an entirely correct form, the facts and statistics available are fairly accurate with reference to Federal and state finances, and can be estimated with reasonable exactness for the local expenditures and results.

The study of a mass of available data leads to certain conclusions that appear so important and so indicative of needs for thorough going revisions, modifications and adjustments of our present practices in highway finance and expenditure, that this paper is presented in two parts—first, the conclusions with only incidental reference to the data upon which the conclusions are based, and second, the supporting data which is too lengthy to be presented before this association. These conclusions are presented in this form for the frank purpose of placing before the public and particularly before the highway executives and legislative bodies facts which indicate the necessity for drastic changes in legislative and administrative highway policies. Also, careful consideration of the data here presented together with other available information leads directly to the conclusion that unless major changes are made in administrative and engineering highway policies we cannot hope for a reduction of expenditure or a decrease of the taxes necessary to provide the annual costs of highways unless this be at the sacrifice of the capital investment through deterioration or loss to the public through avoidable waste in highway transportation. These conclusions cover a wide range, but aim to touch phases of the subject of highway finance which are presently of outstanding importance.

Conclusions

1. The major responsibilities of the public business of the nation fall most heavily upon the local rural and urban governments, next upon the Federal government and least upon the State governments. The ratio fixed by 1923 expenditures is about 5.1 local, rural and urban; 3.5 Federal, 1.5 State.

2. Federal expenditures over several years for highways are about 2.5 percent of total Federal budget. For 1925, the peak, about 3 percent of 1925 total Federal expenditure.

3. The failure of one governmental agency to do a full share of any activity common to all does not lessen the total expense for this activity, but only shifts the burden between budgets.

4. There is a direct relation between bonds and progress in the construction of durable roads evidenced by the fact that only those states which have issued bonds have made any considerable progress in the mileage of durable pavements built. At the end of 1924, of the 467,000 miles of surfaced highways reported, 65.8 percent were low type, 24 percent were medium, and only 10.2 percent consisted of the more durable forms of pavement.

5. The pay-as-you-go policy adopted by a considerable number of states is having two principal effects. First, to limit the expenditure of funds to types of road that admittedly are not adequate for present traffic. Second, to force upon the counties bond issues. In 24 states which have no state bond issues there have been issued since 1921 upwards of one-half bil-

lion dollars in county road bonds, and these same states had issued prior to 1921 about the same amount in road bonds, again supporting the conclusion above that the failure of one governmental unit to carry a full share of the cost of this public undertaking is only shifting the burden to other units of government and increasing rather than decreasing taxes.

6. Of the funds available for expenditure under the supervision of the state highway departments in 1924, 15.9 per cent was transferred from counties, 16.5 percent came from Federal aid, 40 per cent from motor vehicle fees and gas tax. That is, 72.4 percent of the total state highway program estimated at $555,000,000 was financed other than by using the credit of the states or the general taxing power of the states.

7. That the financing of the state highway program through contributions from the counties is wrong in principle and will cost the public more in the end.

8. Interstate traffic is indicated for a number of representative states at upwards of 18 percent of the total on the state highway system. The funds available from Federal aid for the 1924 state highway program amounted to 16.5 per cent of the total. Considering only the funds available for the state highway program it appears there is a reasonable contribution from the Federal government. Considering the whole program, state and local, the contribution from Federal funds amounts to an average of not over 7.5 per cent or 8 percent.

9. Principles of highway finance adopted by the American Association of State Highway Officials are supported by the evidence now available.

10. A greater percentage of state highway funds should be expended for more durable construction, and the state highway departments should be financed without recourse to county contributions.

11. The states must extend the super-

GROUP ONE

Major governmental functions primarily exercised without financial interdependence of governmental units

Federal	*State*	*Local Rural*	*Local Urban*
War Debts and Obligations	Soldiers' Bonus	Local Government	Local Government
Federal Government	State Government	Public Schools	Public Schools
Army and Navy	Higher Education	Eleemosynary	Sanitary Provisions
Postal Service	Eleemosynary	County Courts	Water Supply
Indian Affairs	State Courts		Fire Protection
Prohibition Enforcement			Police
Business Service			Street Cleaning
Special Services to Education and Labor			Waste Collection and Disposal
			Charity

GROUP TWO

Major governmental functions involving financial interdependence

Federal	*State*	*Local Rural*	*Local Urban*
Federal Aid to Agriculture	State Aid to Schools and Agriculture	County Aid to Agriculture	

GROUP THREE

Major governmental functions providing recreational facilities

Federal	*State*	*Local Rural*	*Local Urban*
National Parks	State Parks	County Parks	Parks
			Recreational Facilities

GROUP FOUR

Major governmental functions and sources of income for regulating or providing transportation facilities

Federal	*State*	*Local Rural*	*Local Urban*
Interstate Commerce Commission	State Highway Department	County Highway Department	City Highway Departments
Bureau of Public Roads	Motor Vehicle, Railroad or Public Utilities Commissions	Highway Police	Traffic Police
Waterway Appropriations for Road Aid	General Appropriations for Roads	General Appropriations for Roads	General Appropriations for Roads and Streets
Appropriations for Forest Roads	Special Taxes for Roads—License —Gas	Road Bonds	Road and Street Bonds
River and Harbor Appropriations	Road Bonds	Convict Labor for Roads	Special Assessments for Streets
	Convict Labor	Special Assessments for Roads	Appropriations for Harbor, Port
	Canals, River and Harbor or Port Appropriations		

vision of their state highway departments over a larger mileage of local roads to insure their maintenance, thus preserving the investment. Unless this is done we are headed toward larger local expenditures for highway purposes or a depreciation of roads already built.

Responsibilities of Various Governmental Agencies

The various major activities which the public has undertaken to perform for itself through the Federal, state and local governments and requiring the expenditure of public funds, are shown in the accompanying schedule. The extent of taxing power exercised by these governmental units and the allocation of the funds produced through taxation to the various activities are determined by the constitutions of state and nation and the laws of the legislative bodies or by direct popular vote. The funds, therefore, allocated to any one activity as a whole may be fixed by the action of several or all of the government units.

The Federal Highway System

The original system of roads on which all Federal funds are used was fixed by law at a minimum of seven per cent. This system now includes 179,000 miles.

There have been improved or improvement provided for up to July 1, 1925, 57,560 miles with Federal and state funds. Improvement with State funds only of more than 65,000 miles brings the total to more than 122,500 miles. Since this system is coincident but not coextensive with the State Systems, this discussion will consider the combined Federal Highway System and State highways under one class.

Highway Improvement Status

On the basis of one billion dollars annual expenditure, the average annual cost of our public roads is approximately $300 per mile.

The total rural highway mileage of the United States at the end of 1924 amounted to 3,002,916 miles. The responsibility for the improvement and maintenance of these highways is divided between the highway departments of the several states on the one hand and the counties and townships on the other. These two types of control may be called state control and local control. Of this total highway mileage 259,721 miles, or 8.6 per cent were under the supervision and control of state highway departments; The local control extended over 2,743,195 miles, or 91.4 per cent of the country's total highway mileage. The significant fact is that such a small part of the total highway mileage is found to be under direct or indirect control of state highway departments. The counties and townships and local road districts are still responsible for the construction and maintenance of by far the larger portion of all the highways. The relationship of the importance of the highways under these two types of control so far as traffic conditions are concerned is a wholly different matter.

No definite or uniform policy has been followed by the states in determining the amount of mileage that should be placed within the control of the respective state highway departments and the amount of highway mileage which should be left to the counties and townships to maintain as had been the policy prior to the establishment of any centralized supervision or control on the part of a State. As has been indicated above the state highway system mileage averages 8.7 per cent of the total mileage. In 29 of the states the mileage under state control comprises less than 10 per cent of the total highway mileage of these respective states; in 17 states it ranges between 10 and 20 per cent; in Vermont it is 30 per cent, and in Rhode Island 32.8 per cent. Oklahoma has the smallest proportions of its highway mileage under state control; the percentage there is 4.9 per cent. The tendency, therefore, seems to be to keep the mileage of the state highway systems down to the main travelled highways and important traffic routes.

The total surfaced highway mileage of the country at the end of 1924 was 467,865 miles which was 15.6 per cent of the country's total rural road mileage. This includes the surfaced mileage of the state highway systems and also that part of the surfaced highway mileage which is under control. The ratio of surfaced mileage to the total highway mileage differs widely in the various states. While the average is 15.6 per cent, the usual ratios range from 1.1 per cent in Kansas to 49.5 per cent in Indiana. Indiana is the only state of which it may be said that approximately as much as half of its highway mileage is improved with some type or other of surfacing. The extent to which this surfacing of highway mileage has been carried on can best be shown in the accompanying tabulation which presents a grouping of the seevral states in accordance with ratios of surfaced mileage to total mileage:

RATIO OF SURFACED MILEAGE TO TOTAL MILEAGE

0-9 Per cent	10-19 Per cent	20-29 Per cent	30-39 Per cent	40-49 Per cent
Arkansas	Arizona	Alabama	Florida	Indiana
Iowa	Colorado	California	Idaho	New Jersey
Kansas	Connecticut	Kentucky	Massachusetts	
Missouri	Delaware	Maryland	New York	
Montana	Georgia	Michigan	Ohio	
Nevada	Illinois	Minnesota	Vermont	
New Hampshire	Louisiana	North Carolina	Washington	
New Mexico	Maine	Oregon	Wisconsin	
North Dakota	Mississippi	Rhode Island		
Oklahoma	Nebraska			
South Dakota	Pennsylvania			
West Virginia	South Carolina			
Wyoming	Tennessee			
	Texas			
	Utah			

In 13 of the states the surfaced mileage ratio is less than 10 per cent of the total mileage; in 15 states it is between 10 and 19 per cent; in 9 states it is between 20 and 29 per cent; in 8 states it is between 30 and 39 per cent, and in 2 states the surfaced mileage ranges between 40 and 49 per cent. These percentages indicate on the face of it the extent to which highway improvements of various kinds have been attempted by the several states. It is not an accurate indication, however, of the quality and character of such improvements. That will be shown later when an analysis of the various types of surfacing will be made.

The total surfaced highway mileage of the country is 467,905 miles. That part of this surfaced mileage which is included within the state systems is 128,347 miles, or 27.4 per cent; 339,558 miles, or 72.6 per cent, are included within that part of the highway mileage which is under the control of counties and townships. While the state highway systems comprise only 8.7 per cent of the country's mileage they do include 27.4 per cent of all of the surfaced mileage.

The state highway systems consist of 259,721 miles. Of this total amount, 128,347 miles, or 49.5 per cent, are surfaced and 131,374 miles, or 50.5 per cent are unsurfaced. Of the state highway systems it can be said that about half the mileage is surfaced.

The total mileage under local control is 2,723,195 miles. Of this amount, 339,558 miles, or only 12.4 per cent, are surfaced and 2,383,637 miles, or 87.6 per cent, are unsurfaced. While there are more miles of surfaced highways in the local systems than in the state systems, the ratio of surfaced mileage to the total mileage in the state systems is greater in the state systems than the corresponding ratio in the local systems.

The 467,905 miles of surfaced highways in the United States are improved with various kinds of surfacing. The amount of each type of surfacing and the percentage which that mileage bears to the total surfaced mileage is set forth in the accompanying tabulation.

SURFACED HIGHWAYS, END OF 1924

Type of Surfacing	Miles	Pct.
Sand-clay	63,681	13.6
Gravel, untreated	244,282	52.2
Waterbound macadam	60,234	12.9
Surface treated macadam and gravel	26,680	5.7
Bituminous macadam	17,539	3.7
Sheet asphalt	2,260	.5
Bituminous concrete	7,443	1.6
Cement concrete	31,146	6.7
Brick	4,319	.9
Miscellaneous	10,318	2.2
Total	467,904	100.0

These types of surfacings may be grouped as follows:

Type of Surfacing	Miles	Pct.
Low	307,964	65.8
Medium	112,250	24.0
High	47,691	10.2
	467,905	100.0

In the low type group are included the sand-clay and the untreated gravel types; in the medium group are included the water-bound macadam, the surface treated macadam and gravel, and the bituminous macadam. There are also added to this group 7,796 miles of miscellaneous roads which are found in the State of Pennsylvania and which that State failed to classify. It is believed though that most of the roads referred to may be regarded as of medium type. The high type group includes pavements of all kinds, such as sheet asphalt, bituminous concrete, cement concrete, brick, and 2,521 miles of miscellaneous roads which consist for the most part of wood, asphalt, or stone block surfacing.

These percentages relate only to the total surfaced mileage. Of this surfaced mileage it may be said that roughly two-thirds of all the surfaced mileage is of a low type of surfacing, one-quarter is of a medium twpe, and about ten per cent is of the high type.

The progress which has been made with

respect to the surfacing of highways of the country can best be shown in the accompanying tabulation.

HIGHWAY IMPROVEMENTS IN THE UNITED STATES, END OF 1924

	Miles	*Pct.*
Unsurfaced highways	2,535,010	84.4
Low type surfacing	307,964	10.3
Medium type surfacing	112,250	3.7
High type surfacing	47,691	1.6
Total	3,002,915	100.0

These figures of highway mileages of surfaced and unsurfaced highways and the corresponding percentages tend to mislead the reader and make him conclude that the improvements and surfacings made thus far serve the public in a very inadequate manner. In this connection it must be borne in mind that the highway traffic of this country is not distributed uniformly over the country's total highway mileage. If that were the case, then we could say that only 15 per cent of the traffic was afforded surfaced highways.

During this period the total highway mileage increased from 2,151,379 miles to 3,002,916 miles, or 13.9 per cent. The surfaced mileage, during the same period, increased from 153,530 miles to 467,905 miles, or a three-fold increase. In 1904 the total surfaced mileage constituted 7.14 per cent of the country's mileage; by the end of 1924 this percentage relationship had risen to 15.6 per cent. These increases in the number of miles of surfaced highways and the percentage increases do not by any means indicate the exact extent or degree of highway improvements. The actual types of surfacing are better evidences of the nature of the improvements. Prior to 1914 the data available do not show the various kinds of surfacings. In the accompanying tabulation a comparison is made for the years 1914, 1921 and 1924.

Federal Income and Expenditures

The report of the Secretary of the Treasury for the fiscal year 1925 shows:

Receipts, sources:

Income and profit	47 per cent
Misc. internal revenue	22 per cent
Customs	14 per cent
Foreign obligations	5 per cent
All other	12 per cent
Total collections	$3,780,148,000
Total expenditures	3,529,643,000
Surplus	$ 250,505,000

Expenditures:

1. Public debt retirements chargeable against ordinary receipts	$ 466,000,000
2. Special expenditures, which include interest on the public debt, tax refunds, postal deficiencies, Panama Canal, operations of Shipping Board, War Finance Corporation, and other special accounts, purchase of obligations of foreign governments, investment of trust funds, and other items of similar nature	1,226,000,000
3. General expenditures, which include the legislative establishment, executive proper, the ten departments, the Veterans' Bureau, other independent offices and commissions, and the District of Columbia	1,837,000,000
Total	$3,529,000,000

General expenditures equal 51 plus per cent.

Character of General Expenditures:

1. War and Navy	$708,000,000
2. Veterans' Bureau	385,000,000
3. Pensions	218,000,000
4. All other Federal Depts. and Independent Establishments	526,000,000

This fourth division is approximately 29.5 per cent of General Expenditures, or

COMPARISON OF TYPES OF SURFACED ROADS, 1914, 1921 AND 1924

Type of Surfacing	—1914— *Miles*	*Pct.*	—1921— *Miles*	*Pct.*	—1924— *Miles*	*Pct.*
Sand-clay	44,154.7	17.2	63,339	16.3	63,681	13.6
Gravel	116,058.1	45.1	199,899	50.5	244,282	52.2
Waterbound macadam	64,898.4	25.2	58,036	14.7	60,234	12.9
Surfaced treated macadam & gravel	.....	.....	19,309	4.9	26,680	5.7
Bituminous macadam	10,499.8	4.1	10,264	2.6	17,539	3.7
Sheet asphalt	.....	.....	1,601	.4	2,260	.5
Bituminous concrete	.....	.....	4,978	1.2	7,443	1.6
Cement concrete	2,348.4	.9	15,611	3.9	31,146	6.7
Brick	1,593.4	.6	3,333	.8	4,319	.9
Miscellaneous	17,738.2	6.9	11,390	2.9	10,318	2.2
Total	257,291.0	100.0	387,760	100.0	467,905	100.0

29.5 per cent of 51 per cent of total equals say 15 per cent of total ordinary, just slightly in excess of one-seventh of total Federal Government expenditures for 1925.

For what purposes—1925—warrant basis:

Indian affairs	$ 39,000,000
Highways	105,000,000
District of Columbia	33,000,000
Treasury	128,000,000
All others	221,000,000

Included in this last—All others—are: Legislative establishment, the executive proper, the Civil Service Commission, the the Employes' Compensation Commission, the Federal Board for Vocational Education, the Federal Reserve Board, the General Accounting Office, the Inter-State Commerce Commission, the Federal Trade Commission, the Tariff Commission, and all activities of the Department of Agriculture (exclusive of good roads), Commerce, Interior (exclusive of pensions and Indian affairs), Justice, Labor and State.

Secretary Mellon, in his report, page 21, says: "We still make, as a result of the war, tremendous expenditures for debt retirements, interest on the debt, care of disabled veterans, etc., but these are unavoidable and will be necessary for many years to come. It is the inevitable price which we continue to pay for the war. In this connection it is of interest to point out the proportion of Government expenditures which are due to war. While it is not possible to segregate entirely all expenditures which might fall in this category, if we add to the disbursements for public debt retirements interest on the debt, War, Navy, Veterans' Bureau, and pensions, other extraordinary expenditures, such as adjusted compensation and the increased outlays by the Treasury, the expenditures which are directly or indirectly attributable to war and the national defense compose over 80 per cent of total Federal expenditures. The amounts spent by this Government in aid of agriculture and business, for science, education, better roads, and other constructive efforts are insignificant when compared with outlays due to war and national defense. This will be the inevitable situation as long as war is the method of settling international disputes. These facts should be faced squarely by those who clamor for reduced Government expenditures and at the same time oppose the world's efforts to devise rational methods for dealing with international questions."

Of the total Federal expenditures, $3,530,000,000, the combined Federal aid and forest highway payments were $105,000,000, or approximately 3 per cent of the total. This is the peak and represents neither past nor future average. Probably at present rate the average over several years will be about 2.5 per cent or less.

By doing away with the entire Federal road program the taxpayer without dependents on, say, $5,000, income tax $37.50, would save about 88 cts.

GOVERNMENTAL EXPENDITURES 1823

		Per Capita
Federal	$3,648,000,000*	$33.20
State	1,310,000,000*	11.82
Local	5,142,000,000§	46.41
Total	$10,100,000,000	$91.40

* Actual. § Estimated.

ESTIMATED TOTAL HIGHWAY AND STREET EXPENDITURE COMPARED WITH TOTAL EXPENDITURES ALL PURPOSES

	Expenditures for Highways	*Total Expenditures All Purposes*	*Ratio of Highway Expenditures to Total Expenditures*
Federal Government	$ 90,000,000	$3,648,000,000	2.5 per cent
State and Local Governments	1,210,000,000	6,452,000,000	18.7 per cent
Total	$1,300,000,000	$10,100,000,000	Avg. 12.9 per cent

TOTAL INCOME AND FUNDS AVAILABLE FOR HIGHWAY PURPOSES BY AND UNDER SUPERVISION OF STATE HIGHWAY DEPARTMENTS 1924

	Amount	*Per Cent*
State highway bonds and notes	$101,653,327	18.3
State tax levied for highways (T)	18,282,878	3.3
Appropriation by state for highways (T)	20,084,324	3.6
Miscellaneous state income for highways (T)	13,349,610	2.4
Motor vehicle fees for use on roads	174,816,973	31.4
Gasoline Tax Applicable to Highways	47,810,615	8.6
Transferred funds from counties, etc. (T)	87,998,486	15.9
Federal aid	91,400,832	62.5
	$555,397,045	100.0
The sources of the above funds are:		
Funds from loans	$101,653,327	18.3
Funds from taxes (T)	139,715,298	25.2
Funds from motor vehicles	222,627,588	40.0
	$555,397,045	100.0

ROADS BUILT AND SURFACED IN 1924 BY OR UNDER SUPERVISION OF STATE HIGHWAY DEPARTMENTS

	Miles	Miles
Earth roads established to grade and drained		5,956.6
Surfacing work—		
Sand clay	1,384.8	
Untreated gravel	7,659.8	
Waterbound macadam	467.1	
Surface treated macadam and gravel	999.5	
Bituminous macadam	996.9	
Sheet Asphalt	119.9	
Bituminous concrete	564.4	
Cement concrete	4,850.6	
Brick	161.6	
Miscellaneous	2.8	
Total surfaced mileage		17,207.4
Total mileage		23,164.0

ROADS BUILT AND SURFACED BY COUNTIES AND TOWNS IN 1924

	Miles	Miles
Unimproved and earth partially graded		6,407.7
Earth to established grade and drained		7,732.6
Surfacing work—		
Sand-clay	1,615.2	
Untreated gravel	8,805.1	
Waterbound macadam	966.1	
Surface treated macadam and gravel	467.7	
Bituminous macadam	903.3	
Sheet asphalt	95.9	
Bituminous concrete	167.0	
Cement concrete	1,229.3	
Brick	25.9	
Miscellaneous	58.2	
Total surfaced mileage		14,333.7
Total mileage		28,474.0

The above figures do not include the following states, for which data could not be obtained:

Delaware	Pennsylvania
North Carolina	Virginia
Oregon	Nebraska
Vermont	Oklahoma
West Virginia	Utah
Kansas	Washington
Ohio	

Interstate Traffic

The traffic crossing state boundary lines is for the most part a local movement. In Pennsylvania at stations within 16 miles of the state line it was noted that almost half of the passenger cars were foreign cars and about a third of the motor trucks.

The foreign passenger car and motor truck movement noted at interior points in Pennsylvania shows that 12.4 per cent of the passenger cars were foreign cars and 1.8 per cent of the motor trucks. These interior points taken as samples were distant from the state line from 42 to 110 miles. The average distance of these stations from the state line was 62 miles.

A similar study in Ohio shows that at interior points distant on the average 68 miles from the state line the foreign passenger car averaged 16.8 per cent of

CALENDAR YEAR BASIS

	Number of Motor Vehicle Registrations	*Population of United States*	*Persons per Vehicle*
1909	312,000	90,691,000	291.0
1914	1,711,000	97,927,500	57.0
1919	7,565,000	105,003,000	13.9
1924	17,592,000	112,079,000	6.4
1925	20,100,000*	113,494,000	5.6

* Estimated.

Calendar Year Basis	*Excise Tax (Began 1918)*	*Motor Vehicle Receipts (Began 1905)*	*Gas Tax Receipts (Began 1919)*	*Total*
1909		$943,000		$943,000
1914		12,382,000		12,382,000
1919	$48,834,000	64,697,000	751,000	114,282,000
1924	139,202,000	225,492,000	79,987,000	444,681,000
1925	130,000,000	256,000,000	165,000,000	551,000,000
Personal property, 1925				$100,000,000
Municipal and local licenses, 1925				10,000,000
Total, 1925				551,000,000
ESTIMATED TOTAL				$661,000,000

the total passenger cars and the motor trucks 4.5 per cent. These stations ranged from 41 to 120 miles from the state line.

Taking all the stations in *Ohio* into account we find that the foreign passenger cars amount to 18.6 per cent and the foreign motor trucks 7.4 per cent.

In *Pennsylvania* the foreign passenger cars were 17.7 per cent and the foreign motor trucks 8.2 per cent.

In *Connecticut* 21.1 per cent of passenger cars were of foreign registration and 10.9 per cent of the motor trucks were of foreign registration. These foreign vehicles make a proportionately larger use of the highways than the local vehicles. The passenger car mileage of the foreign cars was 43.4 per cent of the total passenger car mileage; the foreign motor truck ton-mileage was 32.8 per cent of the total motor truck mileage.

On the primary roads of *Maine* the foreign passenger cars were 23.3 per cent of the total number of passenger cars and the foreign motor trucks only 2.1 per cent.

COMPARISON OF CITY-OWNED AND FARM-OWNED PASSENGER CARS ON THE RURAL HIGHWAYS

Pennsylvania—On the basis of a small sample it was found that the city-owned cars constituted approximately 95 per cent of the total number of passenger cars on the highways, and the farm-owned cars constituted 5 per cent.

Maine—The summer's survey in Maine showed that the city-owned passenger cars amounted to 94.6 per cent of the passenger car traffic, and the farm-owned passenger cars amounted to 5.4 per cent.

Ohio—On the basis of a number of representative stations it was found that city-owned passenger cars comprised approximately 93 per cent of the passenger-car traffic and the farm-owned cars were 7 per cent.

COUNTY BONDS (ROAD AND BRIDGE) SOLD DURING YEARS 1921-22-23-24 IN STATES HAVING NO STATE BONDS

State	*Total sold in 4 years 1921-24, Incl.*
Arizona	$ 4,907,000
Arkansas	26,808,265
Connecticut	1,157,500
Florida	31,312,143
Georgia	6,348,924
Indiana	55,415,420
Iowa	16,195,831
Kansas	14,686,057
Kentucky	7,905,978
Louisiana	28,088,237
Minnesota	36,904,477
Mississippi	10,020,212
Montana	2,501,800
Nebraska	3,890,769
North Dakota*	.....
Ohio	40,511,219
Oklahoma	16,681,300
South Carolina	22,189,248
Tennessee	10,929,830
Texas	25,278,200
Vermont*	.....
Virginia	9,042,015
Washington	5,273,500
Wisconsin	26,982,237
Total (24 states)	$403,030,162
Outstanding Jan. 1, 1921	431,662,500

* No information available.

FUNDAMENTALS IN MIXING AND LAYING CEMENT CONCRETE

By C. M. Ziegler, Division Engineer, Michigan State Highway Department, Lansing, Mich.

(Paper read at Twelfth Annual Conference on Highway Engineering, University of Michigan, Ann Arbor, Feb. 15, 1926.)

I have confined the subject of this paper to concrete in pavements. Concrete in structures is a subject worthy of individual attention. The subject has been covered many times, and in far better manner than I am able to do here. Every set of specifications for this type of construction covers it in detail.

The first concrete pavement of record in the United States was that laid at Bellefontaine, Ohio, in the early nineties. The amount laid would make about ½ mile of equivalent 18 ft. pavement. From this date until about 1909 many small pieces of concrete pavement were laid, mostly in the nature of experiments. From the year 1909 to the present date the popularity of this type of pavement both for country and urban use has grown by leaps and bounds. This is evidenced by the fact that the total amount of cement concrete pavement laid in the United States to the end of 1909 was about 450,000 sq. yds., which has grown to the enormous sum of 615,561,000 sq. yds. to Jan. 1, 1926. Of the above yardage, about 197,233,000 sq. yds. has been laid in cities and villages. The equivalent of 18 ft. pavement of the total yardage to Jan. 1, 1926, in the United States is about 58,280 miles. The development of cement and the knowledge of its use, as well as the development of equipment for the proper and economical handling of cement concrete, together with the suitability of this mixture of materials for modern pavement construction, have been responsible for its widespread use.

Practically all of this concrete pave-

ment in the United States has been constructed since 1914. A great deal of the earlier constructed yardage has been replaced. The cause of failures in some instances, and the necessity of replacement of the earlier concrete pavement in others, has been partly due to the inadequate design of that time to carry the enormous loads required of a pavement under the traffic of today; partly to the improper alignment and insufficient widths to serve this traffic; partly to the lack of suitable equipment to get the best and necessarily uniform results out of the combination of materials; and in great part to the general lack of knowledge and application of the very fundamentals of the mixing, handling, placing and curing of cement concrete to secure the quality and uniformity of construction demanded of it that it might hold its existence under our modern traffic.

A well mixed and properly laid concrete is not necessarily all that is required to make an ideal pavement, adequately able to withstand the forces of nature and the rigor of present-day traffic. Intelligent survey and a thorough study of location and design is necessary so that the pavement may be placed where it will best fit the locality and serve the traffic it is to carry. The grades must be such that they will not restrict traffic or be dangerously steep when it is slippery. The curves must be easy and safe for high speeds. The pavement must be designed wide and strong enough to carry the maximum volume of traffic safely and without extreme congestion, and the heaviest traffic for which it is designed without failure. The plans and specifications should be drawn up complete and clear and in sufficient detail so that there will be no doubt as to their meaning in the mind of the field engineer in charge of construction. Width of right of way, general appearance and beauty, and provision for future widening if reasonable to expect that traffic will demand it, must be given consideration.

Adequate drainage is absolutely necessary. The crown of the pavement and shoulders, the ditches and drainage structures should be so designed that the surface water will be taken care of and gotten away from the road as soon as possible. Soil conditions must be investigated. It is frequently necessary to remove a layer of unsuitable material from the surface of the subgrade and replace it with good stable soil. In some soils and under some conditions, underdrainage is necessary and should be carefully designed to accomplish the purpose for which it is intended.

Materials going into construction must be selected and tested with care. Without the proper quality and uniformity of these materials, the resulting pavement will not be of the desired quality. The right materials can only be secured by the most rigid, thorough and continuous testing by the laboratory. I cannot emphasize too strongly the importance of laboratory testing and control. With uniformly good quality of materials and the proper combination and manipulation of same in the field, a uniformly good pavement will result, providing the preliminary work of location, design and drainage have been properly taken care of.

A reliable contractor with an experienced organization is necessary for the best results. The contractor and his organization must be honestly interested in producing a good job. Unless he is making a fair legitimate profit on his labor and money invested, he will be working under a handicap and in spite of all the efforts of the engineer to maintain the standard of good construction the organization will not function properly and the general quality of the work aimed at is liable to suffer. His equipment must be first class and adequate for handling all branches of the work. The mixer is the pace-setter, and his grading, subgrading, material unloading and loading, and hauling equipment must be such that it will contribute to, and not interfere with, the steady and continuous operation of the mixer. He must always maintain a supply of materials in reserve.

The Fundamentals

The fundamentals of the mixing and placing of the concrete may now be set forth as follows:

1. Intelligent engineering supervision and inspection.
2. Proper handling of the materials.
3. Careful proportioning of the materials.
4. Uniform mixing of the materials.
5. Consistency of the mixed concrete.
6. Forming the subgrade.
7. Forms and form setting.
8. Placing of the concrete.
9. Finishing of the concrete.
10. Curing and protection of the concrete.

Supervision and Inspection

With the best and most uniform mate-

rials, selected with the utmost care and carefully tested by the laboratory, the resulting pavement may be decidedly inferior to the standard set out to get unless these materials have been properly and carefully combined and manipulated in the field. It is the responsibility of the field engineer and, through him, of the inspectors to see that the materials are so handled and mixed, and the resulting concrete placed and finished strictly in accordance with the plans and the intent of the specifications. The specifications generally represent the best known practices at the time of the handling and combining of these materials to get the required grade of construction. The amount of money involved in the materials, labor and profit in the construction of a cement concrete pavement are sufficient to give the right to require the highest class of workmanship. The field engineer in charge of construction should therefore be selected with care. He should be a good capable man of sound judgment, honest and conscientious. He must have good reliable inspectors and sufficient engineering organization under him so that his instructions will be carried out accurately and so that he will have enough time for the general supervision of the work. The inspectors must be selected for their intelligence, integrity, experience and personality. Good inspection is necessary to a smooth-functioning organization which is in turn necessary for a good and uniform quality of work.

Handling of the Materials

We will assume that when the aggregates reach the unloading point if shipped from a commercial producing plant, or when they leave the plant when produced locally, they will be uniformly graded from coarse to fine, free from objectionable matter and meet the specifications in all respects. In unloading these materials and transporting them to the skip of the mixer, care must be taken that they do not become mixed with matter deleterious to good concrete. If they are placed in stock pile when unloaded from the car or when taken from the producing plant, the stock pile must be built up in layers so as to produce as little segregation (thus changing the uniform grading) as possible.

Each car of cement should be tested by the laboratory when loaded and the field engineer notified of the results of this test. If it does not meet the test or has been damaged in transit, it must be kept separate from other cement on hand until it can be removed from the job. The approved cement should be stored under protection from the weather and handled in such a manner that it will not be damaged and will still be first class in every respect when used in the work.

The steel should be stored and handled in such a manner that it will not be bent out of shape or excessively rusted before use.

The expansion joint must not be broken or excessively warped out of shape when used.

Water must be secured from a reliable source and if there is any chance of contamination it should be sampled at intervals and tests made by the laboratory.

Proportioning

Aggregates may be proportioned for the mix decided upon by the inundation method, by weighing, or by measuring. The guessometer method, which was used considerably a few years ago when the importance of accurate proportioning was not so much appreciated, is practically extinct. The inundation method and the proportioning by weight with allowance made for the moisture content in the aggregate, are the more accurate methods. Several states, principally Iowa, have recently tried out this method of proportioning by weight and have used it very satisfactorily. The proportioning by measuring is the most common method used. This method is used in Michigan. It is accomplished by the use of metal batch boxes hung under bins, one for coarse and one for fine aggregate, which can be set to measure the exact volume desired for each batch. These measuring boxes should be accurately computed and set to give the volume of material desired. They should be inspected and checked frequently to see that the setting has not changed and that they are completely filled for each batch. On small jobs when aggregate is stock piled on the subgrade, it is allowed to be proportioned by wheelbarrows. Each wheel-barrow load should be surface struck to insure uniformity of loading. The wheel-barrow method is not satisfactory, however, not only from the standpoint of accuracy and uniformity, but also because of the possibility of the aggregate becoming mixed with undesirable material from the subgrade. The measuring method has to date been considered as fairly satisfactory, especially if the bins are filled from a large stock pile, as the moisture content, except in

extreme weather conditions, does not vary excessively. The relative proportion of fine and coarse aggregate should be varied slightly by the engineer to obtain the maximum density of concrete.

In proportioning the cement one bag of approximately 96 lbs. is regarded as one cubic foot in volume. If the aggregate is transported to the mixer in batch boxes on industrial railway or on trucks, the cement should be proportioned out into separate, tight compartments at the loading station or transported to the mixer in the original sacks and the required amount added to the aggregate in the skip of the mixer.

Mixing

The concrete mixer should be equipped with a skip so constructed that the materials can be dumped from it into the mixer in the shortest possible length of time. The drum of the mixer must have capacity and be so constructed as to mix the entire batch thoroughly and uniformly without spilling out at the ends. The strength of concrete is effected by the degree of mixing. Generally one minute is considered the economical time of mix for a standard mixer after all materials including the water are in the drum. Some engineers, however, are recommending slightly more than one minute mix, believing that the extra strength of the concrete is worth the extra cost. Mixers vary somewhat in ability to produce a uniform degree of mixed concrete in one minute. It might be considered advisable therefore upon investigation of various types of mixers to set a time limit of mixing for each type. As a means of getting a uniform degree of mixing for each batch, each mixer should be equipped with an attachment for automatically controlling the time of mix of each batch and locking the discharge chute until the required time has elapsed.

Consistency

A large part of the latent strength of the mixture of cement and aggregate may be lost by the addition of more water than is necessary to get a good workable mix. The consistency therefore of a concrete mixture has an important bearing on the resultant strength developed. Sufficient water only should be added to give workability of mix. This may be determined somewhat by a slump cone test, the desirable slump for Michigan materials being about 1 in. This may be gauged somewhat visually by observing whether or not the edges of the concrete curl under when dumped from the bucket and the concrete piles up. If the concrete spreads out flat and does not pile up, more water than necessary for a workable mix and than desirable has been added to the mixture.

It is necessary for the inspector to see that the water is accurately proportioned for the batch and that the dribbling of water into the drum, occasioned by a leaky valve or some other cause, is eliminated.

The consistency must be fairly uniform as the shrinkage occurring while the concrete is setting is closely related to the water content. Variation in consistency of the concrete in the pavement will cause uneven shrinkage after it has been finished, thus producing a wavy surface.

Subgrade

The subgrade must be accurately trimmed ahead of the mixer to grade and to the cross section of the bottom of the proposed slab. The subgrading may be done by some form of an approved mechanical subgrader, run on the forms which have been temporarily set to line and grade, or it may be trimmed by hand. All sod, muck, peat or other unsuitable soil must be removed from the surface of the subgrade and replaced with good soil. All loose or lumpy soil must be rolled and compacted with a medium-weight roller. All soft mud must be removed and replaced with dry soil. If sand, gravel or crushed stone has been placed as subbase, it is only necessary that this be trued up to line and cross section.

A subgrade template, preferably of heavy construction with a cutting edge, should be pulled behind the mixer to cut off any high spots there might be in the subgrade. In heavy clay which is so hard that high spots must be taken off with a pick or mattock, it might be advisable to use a lighter template which could be moved back and forth across the subgrade to check same until the high spots have been completely taken off. The subgrade should be accurately and uniformly formed to secure the required thickness and uniform thickness of pavement. The thickness of the pavement should vary but little from that shown on the plans. Extra thickness is not as a rule economical, particularly if the variations are frequent, because the pavement is like a chain which is only as strong as its weakest link and the excess concrete would therefore be an economic waste. It has been determined when cores were taken from pavements where the subgrade was

constructed with care that the variation in thickness of the pavement must not exceed ¼ in. This figure may be a little bit exacting in general, however, where varying types of soils are encountered. One-half inch should, however, be the maximum, ¼ in. each way.

Just prior to the placing of concrete, the subgrade should be moistened, by sprinkling, to a depth of 1 inch or more so that water will not be drawn out of the concrete by the dry subgrade, and cause too rapid setting.

Forms

The forms should be straight and true, and equal to the edge thickness of the pavement. After the subgrader has been run over them they should again be lined up and set to grade. The foundation under them should be solid. If the soil is soft, stakes should be driven in the nature of small piles under the forms to insure sufficient stability under the weight and motion of the finishing machine. After final setting the top of the form should be straight-edged to see that they are true, as it is impossible to strike off a smooth-riding-surface pavement from uneven forms. On vertical curves it is important to see that the two lines of forms break joints exactly opposite. The extra labor and (as some contractors consider it) trouble incurred in getting good form setting is saved in labor in finishing the pavement and better riding qualities.

Placing

The concrete should be deposited on the subgrade from the mixer by means of a bucket suspended by means of a traveler from a swinging boom. A careful operator with the assistance of a spreading device attached to the bucket should be able to deposit this concrete on the subgrade in such a manner that it will require the minimum of shoveling and handling afterward. Hoes and rakes should not be allowed in the spreading, and the concrete should be disturbed as little as possible after placing. It is the policy in Michigan to place 1 in. lateral bituminous expansion joints every 100 ft. in the pavement to allow for future expansion. A central longitudinal parting strip is also used.

In general during late fall or early spring weather conditions, concrete may safely be placed when the general air temperature is 35° F. and is rising and it should not be placed when the general air temperature reaches 40° F. and is falling. Materials containing frost must not be used nor the concrete placed on a frozen subgrade. Concrete placed near the lower limits of temperature given above, however, must be protected from frost damage by covering with straw or by some other means. In emergency cases of extreme nature the aggregate and water should be heated to at least 50° F.

Finishing

The finishing is accomplished by means of a hand strike template sufficiently rigid for tamping or a power finishing machine, but with either method the mixture should be sufficiently compacted to eliminate free water and any voids, and to produce a uniformly dense concrete. Too much tamping with a hand template or too many trips over the surface with a finishing machine is undesirable and it tends to bring the water to the surface and with it the silt content in the sand. All finishing work must be done prior to the initial setting of the concrete and in general this occurs within 45 minutes after mixing. It has been said that the smoothness of a pavement surface, as determined from the seat of an automobile, is the yardstick by which the layman measures the completed payment. If the forms for the pavement are set properly and the concrete is of uniform consistency, all that remains to make a good smooth pavement is sufficient compaction to produce a dense concrete and to strike off the surface enough times to remove excess material, keeping in mind that the depressions must be kept filled with good concrete taken from the body of the batch and not with fine aggregate and cement.

As an aid to the contractor in securing a smooth surface and a check for the engineer, the surface should be tested by the inspector with a 10 ft. straight edge before final belting, and any depressions filled or high spots cut off. The final finish to the pavement surface is procured by belting. This also serves to remove any water which may have accumulated there. After the pavement has set up sufficiently for an inspector to walk on it (preferably the morning after being poured) it should again be straight edged very carefully and any high spots marked. These may be rubbed down with a carborundum brick as soon as the pavement is sufficiently hard to prevent the fine stone particles from being pulled out by the brick, or the spot may be marked and the pavement allowed to cure for about 21 days and the high spot then dressed down by some kind of grinding machine, which will leave the surface smooth and free from pit holes.

The outside edges of the pavement and the edges adjacent to the expansion joints should be rounded to a radius of ¼ in. by a hand finishing tool.

Curing

The final strength of concrete is developed in the curing. It is estimated that from 15 to 25 percent additional strength can be gotten from concrete properly cured over that improperly cured. Proper curing is effected by ponding, that is, keeping the concrete covered with water held on the surface by means of earth dikes; by covering with earth or straw and keeping it wet; or by spreading on the surface a layer of calcium chloride of from 2 to 2½ lbs. per sq. yd. This chloride absorbs moisture from the air and dissolves, thus producing a water covering for the pavement, part of which penetrates into the pavement surface, keeping it moist for some time. If a hard rain occurs shortly after the spreading of the chloride which washes it off the surface, an additional application of 1 to 1¼ lbs. per sq. yd. should be made. No covering is necessary or advisable when chloride is used for curing.

When chloride is applied for curing too soon after the finishing of the concrete it causes scaling of the surface. It is thought by many engineers to be a contributing cause for scaling when applied at any time. It has been observed that when chloride was applied to a pavement for the purpose of removing a coating of ice at least 4 months after the pavement was placed, it caused a very decided and general scaling. This method of curing, therefore, should be used with caution until there is much more definite knowledge of its effects on the concrete.

When the pavement is ponded or covered with earth, the usual practice is to keep water on the surface or to keep the earth wet for a period of 10 to 14 days. As soon as initial set has occurred in the concrete after being finished, it is very good practice to cover the surface with a layer of burlap, keeping same wet, which will protect the surface and aid in the curing until the pavement has set sufficiently to admit of one of the above methods of curing being used.

At the end of 18 days the pavement may be cleaned off, and opened to traffic at the end of 21 days, the greater portion of its strength being considered to have been obtained in that period. All traffic and loads of any magnitude must be kept off the pavement until it is officially opened.

With the work carefully planned and located and with all of the above fundamentals of mixing and placing carefully followed, it is reasonable to expect that a very fine piece of concrete pavement will result. The setting for this pavement is now worthy of consideration. Present day traffic is not only demanding a smooth riding surface, but one also with the right setting. The shoulders and backslopes must, therefore, be trimmed true to cross-section and line. The entire right of way must be cleared of all rubbish, stumps, objectionable brush, advertising signs and everything possible which interferes with nature's beauty. If finances are available, suitable shrubs and trees may be planted along stretches devoid of such vegetation.

With a well constructed, smooth riding pavement in pleasing surroundings, therefore, one may well expect for the job the well merited approval of a pleased public.

SMOOTHING SURFACE OF OLD PAVEMENTS

By H. O. Offutt, District Engineer, Indiana State Highway Department, Vincennes, Ind.

(A paper read at Twelfth Annual Road School, Purdue University, Lafayette, Ind., Jan. 18, 1926.)

Smoothing the surface of a pavement or macadam with bituminous concrete patches, is a very particular job. It is tedious and slow, and unless the gang is well organized, lost motion will develop in many places. We know we are far from perfect in doing this work, but we feel that we are doing fairly well and hope our experience will assist others in doing this work.

How to Obtain a Smooth Surface

A rough surface we know is caused by irregularities, some spots being too high and others too low. The low ones can be filled, but the high ones cause more trouble. These high places can be removed by bush-hammering, but we believe the bush-hammering injures the pavement and shortens its life, so when possible we try to biuld approaches to these high spots which will not cause the car to bounce. Therefore, in smoothing the surface of a pavement we try to fill all the depressions, which cause the car to bounce, with a material which will soon harden and become a part of the pavement.

Bituminous Concrete for Patching

The use of bituminous concrete in making these patches we find gives excellent

results. This kind of concrete is made by mixing an aggregate with a bituminous binder. This mixture when first made is soft and pliable and can easily be spread into the depressions. The volatile matter in the bituminous material soon evaporates and with traffic compressing and compacting the mixture, it soon hardens and a patch is made which wears as good as the original surface.

These mixes are many and varied. In some the materials are mixed hot and in others they are mixed cold. The aggregate is also varied, different kinds of stone and gravel being used and various gradings of the aggregate called for, the bituminous binder being either a tar or an asphalt in some form. In doing work of this nature, we have found we get good results by confining ourselves to the use of a bituminous concrete made with a stone aggregate and a tar binder, and mixing both at normal temperature. We have used other variations and have obtained good results, but in this discussion we will touch only on the kind of mix.

Filling Depressions

The work, while all done at the same time and by the same organization, is actually divided into two processes.

All depressions which require filling, and which are not over ½ in. in depth, are taken care of by a process which we call "paint patching." In this class of work, the depressions after they are marked out, are painted with a hot tar and covered with stone screenings or pea gravel.

The depressions which are over ½ in. in depth, we fill with the bituminous concrete and cover same with a seal coat. The depressions when they are not over 2 in. in depth are painted with hot tar, as in the first case, before the bituminious concrete is applied.

Survey of the Work

After deciding to smooth a rough surface, the first thing to do is to determine as near as possible, the amount of work to be done. The organization can then be planned and the materials and equipment assembled ready to begin work.

Driving and walking over the contemplated work and judging the roughness of the surface will give us some idea of what is to be done. By counting, checking, straight edging, etc., we can get an approximate idea of the number of bumps per mile. We can then prepare an approximate estimate of cost and a bill of material.

Estimate of Work

The conclusions we will give you under this subject are only rough approximates. They are stated for the purpose of giving the superintendent some data to go by in ordering his materials and are not to be used as a specification for doing this work.

From studies made of our work during the past season, we have arrived at the following:

A. The average patch will range in size from 3 to 5 sq. yds. Judgment in the field will have to decide which figure will best suit your piece of work.

B. One square yard of patch requires about—

0.5 gal. tar for painting the depressions.
0.25 gal. tar for mixing the bituminous concrete.
0.25 gal. tar for seal coat.
0.33 cu. ft. of stone aggregate.
0.33 cu. ft. of screenings.

We believe that a road surface which is considered rough will have about 200 patches per mile; one which is very bad will average as high as 700 per mile. Figuring as estimate for repairing one mile of surface having about 200 patches per mile, and figuring 3 sq. yds. as average size patch, we would have the following:

Patches per mile 200
Square yard of patch 600

Materials—

Tar for painting patch	300 gal
Tar for bituminous concrete	150 gal.
Tar for seal coat	150 gal.
Total tar	600 gal.
Stone aggregate for bit. con.	7½ cu. yd.
Stone screenings	7½ cu. yd.
Total stone	15 cu. yd.

Cost of materials—

600 gal. tar	$100.00
15 cu. yds. aggregate or screenings	45.00
Misc. (hauling, crayons, etc.) 10 percent	15.00
	$160.00
Labor, 90 percent	145.00
	$305.00

These figures were the average amounts of material used and turned in on the completion report for a ten-mile project in Warwick County, the surface condi-

tions being about the same as stipulated above.

Organization

When you have a fair-sized job ahead of you, it is best so to organize your gang that one man will keep busy at one or two operations continually. He can soon be taught to do these few operations quickly and easily and then he can go ahead without being watched. A gang organized on this basis should consist of the following:

Foreman

The foreman of the gang has many duties. First of all, he exercises a watchful attitude over the whole gang and keeps things in general going smoothly. He should watch the work of the marker and finisher very closely, as their work must be done right. He checks over the finished work carefully and corrects any bumps which have been left. He usually applies the screenings in making the paint patches and assists the tar man in applying tar when necessary, and moves the equipment along the road as progress is made. A good way for the foreman to keep check on results of his work is to look back over the work occasionally and notice whether cars going at a good rate of speed do any bouncing. Uusually if a bump has been missed or a patch made too high, it can be detected in this way, or if he has a car available he can try it out himself, checking the uneven spots as he drives over the finished work.

Mixers: Two men to mix the tar and stone (making the bituminous concrete) and deliver it to the patching gang.

Marker: One man to measure and mark out the patches. When he gets ahead with marking, he should drop back and assist the wheelbarrow man by loading the empty wheelbarrow for him.

Sweeper: One man to sweep surface when the patch is to be made. This man has some spare time which is taken up by helping the wheelbarrow man, usually by loading his empty wheelbarrow.

Tar Pourer: One man to tend tar kettle, handle and pour hot tar on depression.

Wheelbarrowman: One man to wheel and shovel the bituminous concrete on to the patch.

Finisher: One man to spread the bituminous concrete and finish off the patch.

Equipment

The equipment necessary for a gang of this size should consist of following:

One truck—two-ton capacity.
One truck—one ton capacity.
One trailer—two-ton capacity.
One concrete mixer, 7 cu. ft. capacity.
Three wheelbarrows.
One tar heater, 200 gal. capacity.
One wire push broom
One fibre push broom
One stable broom
One 14 ft. straight edge
One 16 ft. straight edge
Two-two gallon tar pouring cans
Four-ten quart pails
100 ft. common chalk line
One box boilermakers' crayon.
Two finishing shovels

Various square point and round point gravel scoops.

Description of Equipment

The two-ton truck is used to pull the trailer and tar kettle, and also to hold the screenings.

The one-ton truck is used to haul the bituminous concrete from mixing plant to the patching gang and also to haul the men to and from work.

The concrete mixer must be a tilting drum type to give satisfactory results.

The straight edges are 2x6 in., one 14 ft. long and one 16 ft. long. They are best made from cypress, as they should be as light as possible. They are made 2 in. thick to prevent warping. The 14 ft. straight edge is for the finisher and the 16 ft. one is for the marker.

The tar pouring cans are made from galvanized sprinkling cans with the spout cut off about ½ in. from the body of the can, and the remaining part of the spout squeezed almost together, leaving an opening of about ¼ x 5 in. This kind of an opening tends to spread the tar very uniformly, and saves time spreading the tar.

The finishing shovel is a long handled shovel, and should be as light as possible, and have a square point 12 in. wide. A wider point is hard to handle and one more narrow slows down the speed of the finishing. This can be made by putting a long shovel handle in an old gravel scoop. Usually an old scoop will be worn and thin, which makes a light, serviceable tool. The gravel scoop point can be heated and the point flattened out so that it will be level all along the bottom of the point.

The crayons used will run about 36 to the mile, so, often it will not be necessary to buy a whole box.

Materials

The tars used are TP2, TM and TCM. The TP2 is used to paint the depressions, to hold the screenings or bituminous concrete in place, also to be used in making the seal coat, unless there are a large number of sq. yds. to coat, when TM should be used. The TCM is used to mix with the aggregate to make the bituminous concrete.

The aggregate is usually of stone, although in gravel country pea gravel can be used in place of screenings. The sizes of aggregate used are as follows:

No. 6 screenings ½ to ¼ in.
No. 46 screenings ¾ to ¼ in.
No. 3b screenings 1 to ¼ in.
No. 34 screenings 1½ to ¼ in.

We used as large size aggregate as possible in the bituminous concrete, which was to be applied in the depression. To do this, we made three different sizes of bituminous concrete. One size was made out of the No. 46 stone, one out of the No. 3b stone, and one size out of the No. 34 stone. In a depression of ½ to ¾ in. we applied the bituminous concrete or mix made of the No. 46 stone. In one having a depth of ¾ to 1¼ in. we applied a mix made of the No. 3b stone. In one having a depth of 1¼ in. to 2 in. we applied a mix made of the No. 34 stone.

In almost any depression a slightly larger stone size should be used than the measurement will call for. It is always advisable to use as near the proper sized aggregate to bring the surface up to normal as can be used. This, we think, would apply to any patch with a depth up to 4 to 5 ins., using for a 4 in. depression a 3 or 4 in. stone if available.

Mixing Operation

The mixing plant should be located near the road, and moved when necessary, so as never to be more than 2½ miles from the patching gang. At this plant should be kept the aggregates, the tars and the equipment for mixing. The equipment will include the light truck, the mixer, two ten-quart pails, shovels and scoops.

Careful attention should be given to the arrangement and layout of the plant so that all lost motion be eliminated. One good way is to place each size of aggregate in a pile, arranging the piles in a row, so that the mixer can be moved along the row and the aggregate loaded direct from the pile into the loading hopper. The correct amount of aggregate was measured and placed in the hopper and leveled. A line was then painted around the inside, at the height of the leveled aggregate, which would show the leader how much stone to put into hopper for each batch. The barrels of tar TCM should be handy to the mixer, but not in the way. They should be elevated above the ground high enough to place a pail under the bung. A standard molasses gate screwed into the bung saves time in handling the tar and also stops considerable waste.

The mixing is done by two men. One man loads the receiving hopper and brings the tar for the next batch. The other man dumps the mix onto a dumping platform, from which he then loads it into the light truck, ready to be hauled to the patching gang.

The batch must be allowed to thoroughly mix until each particle of the aggregate is completely coated with tar. The stone must be thoroughly dry and free from dust and dirt. Tar and damp stone will not mix, and bituminous concrete made with damp stone and put on the surface will disintegrate and ravel under traffic. A two or three days' supply of stone is kept covered during the night and during rainy weather. In this way enough stone can be kept dry to keep the work going until the wet stone dries out. When a gang is laid up for work a couple of days, it disrupts the organization and it will take about half a day to get them lined out again when they do get started.

For 1 cu. yd. of aggregate, we use from 14 to 16 gals. of tar TCM, this amount being regulated by the size and cleanness of the stone. The temperature also has some bearing upon the amount used.

These two men mix and deliver to the patching gang about 1 cu. yd. of mix per hour. One batch will make about 5 cu. ft. of mix, the average time of mixing a batch being about four minutes, the balance of the hour being taken up in loading and delivering the mix to the patching gang. The average daily consumption of mix for a gang of this size will run from 7 to 8 cu. yds., so by the time the mixers produce this much mix, clean up and get ready for next day's run, their time is pretty well taken up.

Patching Operations

On the way to work in the morning, the patching gang stops at the mixing plant and loads up with materials. The truck is filled with 2 cu. yds. of screenings, on top of which, two or three barrels of tar TP2 is placed. The trailer is

filled, with various amounts of the three sizes of bituminous concrete, depending upon the character of the surface to be patched that day.

Arrangements should be made by the foreman that one of the gang, the first thing in the morning, goes to the tar kettle and starts a fire, so that the tar is ready for pouring when the gang arrives on the job.

Outlining the Depression

This is done with a straight edge or line. It is a rather tedious task and should be done by someone who is a reliable workman. The depression is outlined with crayon, marking where the straight edge and surface begin to separate. The straight edge is laid parallel with the center line of the pavement, about 1 ft. from one edge. Marks are drawn on the pavement, showing the outside limits of the depression, the straight edge is then moved over about 18 ins. or 2 ft. and the marking is continued until the other side is reached or the patch runs out. The marker should also write the depth of the depression just outside the outline so the men applying the bitmuinous concrete will know what size to use.

The marker outlines all depressions of ¾ in. depth that are over 3 or 4 ft. in length. Depressions of this depth, but over 4 ft. long will not cause a car to bounce. Occasionally the marker will find a depression that the 16 ft. straight edge fails to cover. The foreman then assists him with a line, the line being held to the surface on each side of the depression, which is then outlined the same as when using a straight edge. On a place of this kind, the foreman must use his good judgment as the depression might be entirely too long to repair. If the depression is not over 1¼ in. deep, its length over 18 ft., and its approaches to the normal surface are gradual, it would not need filling.

Patching

Following the marker, the sweeper thoroughly cleans the surface, using a wire push broom and a stable broom. The wire push broom is used to scratch up any foreign matter which may be stuck to the surface and the stable broom is used to sweep the dust off.

As soon as the depression is thoroughly cleaned, the tar pourer applies a coat of hot tar TP2 to its surface, except when the depth of the depression is over 2 in. deep. Where the depression is shallow (¼ in. or under) the application is made slightly heavier, as it is to be a part of the paint patch. The tar pourer should use two 2-gal. tar pouring cans instead of one 4-gal. can, as the 2-gal. cans are much easier to handle. After the tar is applied to the depression, he spreads it, using a fibre push broom. We first used a squeegee, but found that the fibre broom made a more uniform spread, the squeegee having a tendency to ridge the tar at its ends, which makes a ridge in the paint patch. This trouble, however, is more noticeable in repairing a rigid pavement than is on a bituminous macadam.

Applying the Screenings (Paint Patch)

On the outside edge of the depression where the depth is under ¼ in. or over the whole depression if it does not exceed ½ in. the dry No. 6 screenings are applied. Judgment must be used in applying the tar and screenings in making these paint patches or feather edging the bituminous concrete patches, more tar and screenings making a thicker mat, being applied at the deeper end so that when finished the patch on its surface will be smooth and level with the surrounding surface. The foreman himself should apply these screenings because it is particular work.

Too many times we find the men applying too thick a coat of screenings. While this extra thickness of screenings is not harmful to the patch as the tar will only absorb so much, it is a waste of material. The dry screenings and hot tar are used for this purpose in preference to a bituminous mix, using this size aggregate, because it is more convenient to handle and finishes off much better than the bituminous mix on these thin patches.

Applying the Bituminous Concrete

After feather edge paint patch has been made on the outer edges of the depression, the bituminous concrete is applied. This is done by two men, the wheelbarrow man and the finisher. The wheelbarrow man brings the bituminous concrete to the depression in a wheelbarrow. Two wheelbarrows should be used, as the marker and sweeper will have time to load the empty wheelbarrow while the other is being emptied.

The wheelbarrow man must place the bituminous concrete where the finisher wants it, namely: close to the feather edging or on the edge of the bituminous concrete previously placed. It is then worked over into place toward the center by the finisher, using the finishing

shovel, until a uniform surface is obtained.

The bituminous concrete in any one depression is usually of one size mix, but if the depth of the depression becomes deeper than 1¼ in. at any place, a mix made of 1½ in. aggregate should be used in these spots. In a case like this, the outer edges of the depression would be taken care of with the feather edge paint patch, the next portion from ¼ to 1¼ in. in depth, with the No. 3b mix, and the portion over 1¼ in. deep, with the No. 34 mix. It is not best to try and use the No. 34 mix to take care of the whole depression as it will contain too many large stones to give a satisfactory and even surface.

Finishing the Patch

There are several things about finishing the patch and obtaining the smooth surface which should be mentioned. The foreman and finisher should insist that the bituminous concrete not be dumped into the center of the depression in a pile. See that it is applied by the shovelful just where the finisher wants it. This allows him to shove it into place with his finishing shovel by pushing it off of the portion already placed, to the surface of the depression. This tends to spread the bituminous concrete more uniformly and eliminates any high or low places after the patch has compacted.

The finisher should always keep his finishing shovel in good shape, so that it will do good work. Often he will find it necessary to remove the gummy substance which will collect on the point of his shovel. This can be done very easily by burning it off in the fire box of the tar kettle. In doing this he should be careful and not ruin his shovel by getting it too hot.

When spreading the bituminous concrete in cool weather, the finisher will find it pays to heat his shovel every few minutes, in order to get a good smooth finish to his patch. Usually the sun is hot and glaring when this work is being done. The finisher can relieve his eyes and also judge much better the smoothness of his patch if he will work with the sun to his back as much as possible. Looking down on the patch from this direction does not cause a glare and the uneven places are much more easily detected.

When the weather is very hot and the bituminous concrete has a tendency to be picked up by traffic, a small amount of clean stone (¾ to ¼ in.) hand scattered thinly over the fresh bituminous concrete will stop this. When the depth of the patch is under 1½ in. we do not tamp the bituminous concrete, but allow the traffic to do the compacting.

Until the finisher is thoroughly acquainted with his work and his eye has been trained to detect the slightest irregularity, he should always test his patch with a straight edge before leaving it. The foreman should not trust too much to the finisher's eye, but should satisfy himself completely that the patch is made satisfactorily.

If the work is smoothing a bituminous macadam surface prior to a surface treatment, the seal coat is not necessary. The surface treatment itself will supply the wearing coat and seal.

When the work has been smoothing a rigid pavement surface, the bituminous concrete portion of the patches must have all the open places closed or sealed. It is best not to do this until the traffic has thoroughly compacted the patch and any unevenness which may have developed has been corrected.

The seal coat is applied by painting the bituminous concrete with a hot tar TM, about 0.25 gals, to the sq. yd., and then coating the surface with our No. 6 screenings at the rate of about 0.25 cu. ft. per sq. yd. If the job is small, or you do not have any tar TM on hand, the tar TP2 will do.

Filling Deep Depressions

At times we are called upon to fill a depression 6 in. or deeper. The depression should be filled with a stone aggregate up to within 2 in. of the normal surface. The size of this aggregate should be our No. 1 (4 in. to 2½ in.). After this stone has been carefully and uniformly spread and is smooth and level, hot tar TP6 or TP2 is applied at the rate of 1¾ gals. per sq. yd. Immediately after this tar application, there shall be evenly spread over the surface, a covering material of No. 34 stone at the rate of 1 cu. yd. to 160 sq. yds. of surface. Upon this bottom course is then applied a 2 in. course of bituminous concrete made of No. 34 stone. After this has been thoroughly compacted, it should be given a seal coat.

If the job is small, it will not require as large a gang as we have outlined. Often not more than three men will be required. In a case where the force is reduced, it is better to have the men make the patches. The superintendent should study the situation, outline the work

and assign the various duties as will best work out with the reduced force.

WHAT'S AT THE END OF THE ROAD?

By Edward C. Elliott, President, Purdue University, Lafayette Ind.

(Abstract of address at Purdue Road School, Jan. 21, 1926.)

The deep sub-foundation of sentiment, of sense and of science, upon which this Purdue University has been erected, was laid by a courageous and far-sighted generation of men. These pioneers, breaking through the ancient frontiers of human privileges, did not, and could not, vision today's far flung development of the extraordinary proposal "to promote liberal and practical education of the industrial classes in the several pursuits and professions of life."

This original mandate has produced throughout the United States a group of institutions, of which Purdue University is a proud representative, wherein there is a keen consciousness of responsibility for being what their founders intended them to be. This, expressed in the language of our day, means that Purdue University has not served its full purpose until all of the people of the state, of whatever class or occupation, have come to realize that the University is a dependable and sympathetic agency, always at their disposal, to aid them in meeting those needs that determine the satisfactions, the happiness and ideals of the life of the ordinary man.

It is from such philosophy as this that those serving Purdue University derive a feeling of gratification from such educational enterprises as is this Road School. This school is one of the signally important units of the scheme of practical education demanded by practical modern life. The teachings carried on here, directly and indirectly, influence every man, woman and child in the state; and many thousands who live beyond the borders of Indiana.

Nowhere in the history of the world is there a more dramatic story than that found on the pages recording the conquering of that one-time wilderness we now know and cherish as the United States. The stages of exploration, of settlement, of unification and nationalization of this conquering epoch may be written around the thrilling work of the path builders. Civilization has traveled a romantic journey from the wild game track and the Indian Trail to those swift, straight, and solid highways of commerce and communication which we possess today. The Constitution was but a blueprint of a nation yet to be. The builders of the roads, the canals, and the railways gave practical reality to the union, one and indivisible.

On such an occasion as this one cannot but feel himself in the presence of new pioneers who are building new roadways for the new civilization already upon us. The modern highway has suddenly assumed a tremendous economic, civic and aesthetic significance for the American people. If our national greatness and our national unity are to be measured by the quality of American genius for opening and smoothing new lanes of travel and of communications, then great new tasks are now ahead of us.

As the successors of the first trail makers, the diggers of canals and the creators of our railways, the crafts and the professions you represent are to exert an influence for good or harm upon every firm, every factory and every home in the state.

Geographically we are one land. Socially and humanly we still have great distances to go before we have become a people of that singleness of purpose upon which our final destiny rests.

All live and forward-looking citizens of Indiana have, I am sure, a deep satisfaction from the progress that has been made during recent years with the road building program of the state. To be sure this program has cost, and will continue to cost, great sums of money. And what appeals to the mass of our people is that this program has been accomplished without heavily mortgaging the future of the state with bond issues. The state has not gone into debt for its new roads even though the owners of many roadsters have acquired mortgages which they are unsuccessfully trying to burn up with gasoline.

That we need the good roads we have there can be no doubt. That we are going to have more and better roads than we have, there can likewise be no doubt. Yet there are some serious minded ones who are beginning to ask questions of consequence. How far will these roads make for a fundamentally better state? How much better off will be the individual citizen of the state when we have forty thou-

sand miles of state highways instead of the present four thousand? In other words, how far will all these new roads make for the permanent solidity and development of our state?

We rightly assume that the roads being built and projected will make for better agriculture. Will these same roads make for an aggressive constructive citizenship determined to promote the best interests of the best rural life?

We properly conclude that the new road program clears the way for certain business prosperity. Will this same program produce better government?

We know that the people of the state want a better and more extensive road system for pleasure driving. Will these people, who already spend not less than three hundred millions of dollars for such travel be willing to spend in taxes as much as one-tenth of this amount for the further improvement of our state schools and our state parks?

These are some of the serious questions which those whose duty it is to think for the future as well as live for the present, are asking. Unless this great modern public undertaking of road construction shall produce something more than those profits that make for material prosperity; unless these roads furnish something for our people besides the means of speed and pleasure; unless they become a new agency by which men come to know and to understand one another better; unless they become the thread by which we are bound more securely to our common heritage of duties and responsibilities, then I say to you that we shall have spent our substance in vain, and that the roads we build today are leading to the land of nowhere, instead of the land of our dreams and our hopes.

Will hard roads make for a soft civilization is a fair and open public question.

BUILDING SAFETY INTO HIGHWAYS

A nation wide movement for greater safety in the construction of highways will follow in the wake of the American Road Builders' Convention held recently in Chicago, according to H. G. Shirley, president-elect of the organization and chairman of the Virginia State Highway Commission.

"It was the general consensus among the 30,000 engineers, contractors and highway officials assembled at the convention that something should be done to check the enormous loss of life in automobile accidents. As a result, safety is now one of the principal things taken into consideration in the construction and location of highways," Mr. Shirley said.

"Perhaps the most prolific source of accidental death to motorists is the grade crossing," according to Mr. Shirley. "In a few cases such crossings cannot be removed without an unreasonable expenditure of money. The majority, however, will be eliminated from the nation's highways, while the scientific location of routes will make a complete abolition of grade crossings possible on the newly built roads.

"Nearly one thousand people were killed in and near Chicago last year by automobiles. A great many of these deaths were the result of careless driving and speeding, but a large number were also caused by roads too narrow to handle the traffic. Highways leading into the large cities are now being planned wider than ever before. Modern safety signals and devices are being adopted in the cities and along the national routes. Curves are scientifically constructed to reduce the possibility of accident, and steep grades removed where possible, to eliminate the dangrs of such places.

"This movement in behalf of safety is not confined to the United States alone," said the Virginia highway official. "It was learned from the hundreds of delegates from Canada, Mexico, Panama, and the South American countries at the American Road Builders' Convention, that such a movement was fast growing in these nations. For that reason it is believed that the 1927 meeting of the highway organization will show great progress along safety lines. Detailed reports of deaths caused by improperly constructed and routed highways will be greatly decreased.

In speaking of the 1926 road building program of the nation, the president-elect was very optimistic. "The United States registers approximately ninety percent of all the automobiles of the world. The country should, therefore, possess a highway system of comparative extent. Of the three million miles of highways in the country, a small portion is improved. The program of 1926 will not only greatly increase the system of hard surfaced roads, but will as greatly decrease the death hazards on the present highways."

AESTHETICS IN HIGHWAY ENGINEERING

By Prof. L. H. Provine, In Charge Department of Architecture, University of Illinois, Urbana, Ill.

(Read at Short Course in Highway Engineering, University of Illinois, Urbana, Feb. 26, 1926.)

As we ride over the 4000 miles of concrete highways in this great State of Illinois we are proud of the wealth represented and the foresight and perseverance of those who have made possible this great achievement. This great white ribbon running the length and breadth of the State has brought the great out-doors to us. It has made possible the enjoyment of nature with her trees and fields, rivers and hills.

In a state so young as Illinois, in a nation so young as these great United States, the thoughts, energies and plans have been concentrated on a struggle for existence. Some have excused the fact that we have given little thought to the beautiful to this struggle for a living. We have now reached a point where we have the comforts and the luxuries of life and can pause, figuratively speaking, a moment for breath and take stock to see if the job which has been done is the best that could be done and one of which we can be proud.

In the consideration of the subject, Aesthetics in Engineering and more particularly Aesthetics in Highway Engineering, the magnitude of the subject causes one to wonder where to begin and what can be said in a short time which might be inspiring and helpful. Men have spent their lives in trying to present this subject, many volumes have been written along this line; it is therefore rather presumptuous of the speaker to even suggest this subject for presentation in the time allotted on the program.

What is aesthetics?—The usual definition of this word is typified by the long haired individual, man or woman, thin, nervous, irritable, stoop-shouldered, and with poor digestion, who works when he feels like it, usually from sunset to dawn, who likes to do the unusual, but is just plain queer. Let us have sympathy rather than censure for such individuals as they are fooling no one but themselves.

What is true aesthetics? As an adjective the word is defined as "pertaining to beauty, taste, refinement". As a noun it is "the philosophy of the beautiful; the principles underlying beauty".

Aesthetics in this paper is considered as "the principles underlying beauty". In order that we may understand the meaning of beauty or the beautiful, it should be remembered that prettiness and beauty are non synonymous and cannot be used to describe the same thing. A pretty thing is not always beautiful and something beautiful is much more than being pretty.

Again we turn to the definitions of words and it is found that pretty is defined as "A form of beauty of delicate or inferior kind, delighting the fancy rather than the imagination. Pleasing the slighter elegancies of form, feature, arrangement, or design". But what is the meaning of beautiful, "that which appeals or gratifies that sub-conscious self, sometimes referred to as the inner man. Certain properties of form resulting from the harmonious combination of diverse elements into a whole or into a unity". It is the beautiful in things that is being presented at this time.

The common practice or the accepted theory today is widely different from that of the ages past. We look back at the results of the efforts of those people who created things centuries ago and who left us buildings, roads, bridges, and other structures which we admire and take for granted that such things should have been made beautiful but at the time they were built little did the builders know that they were not only to serve utilitarian purposes then but would stand as monuments for centuries to come. They built for their present needs just as we do now but they believed that everything which is to be seen should be beautiful and so built.

What of today? Do we think of anything except the structural and utilitarian purposes for which the structure is intended? Do we consider that any structure to be successful must combine a third element with that of strength and utility—that third part being beauty? Of two bridges designed for the same conditions, one a perfectly plain structure with no attempt at making it interesting to look upon but all the effort concentrated on making it safe, the other safe and strong but with some consideration given to making it interesting to look upon, which of the two will be chosen by three people out of five? Those choosing the interesting design may not know why they like it better but it makes an appeal to them that the other bridge does not.

Today the aesthetic side, please keep in mind the definition of aesthetics used in this paper, of our everyday life has been left to the so-called artist or one who presumably is a specialist, one having creative ability and imagination and the question of strength and utility is left to the engineer and no thought is given to the fact that the three should enter into every structure. This division of responsibility is a logical one under our present condition, dating back only a few years and caused by the development of new materials with which to work. In the days when brick, stone and mortar were the building materials, it was possible for one mind to know all there was to know in connection with the use and the limitations of these materials. With the introduction of steel, reinforced concrete and other new structural materials which made possible the complicate structures of today as represented by the high office building, the long transmission lines, the building of roads on all kinds of soil for all weather conditions and for ever increasing loads, it became impossible for one mind to know all of those materials and the age of specialization began.

This division of responsibilty has been commonly accepted without thought or argument and we have today the structural steel specialist, the concrete specialist, the hydraulic specialist, the highway specialist. This is as it should be under our modern conditions, but each of us has been content to settle in our narrow field and each has been indifferent to the others. The aesthetic individual has been content to design from his point of view and giving no thought to the structural elements, having the attitude that the other fellow can worry about that and the engineer has designed his structure for utility and safety and has said "Why should I be concerned about how it looks?"

This is the age of specialization and rightly so, not only in engineering and architecture but in all of the learned professions, such as medicine, dentistry, law, and all others. The field of knowledge and application is so large that life is too short for one mind to master all of the ramifications of any calling. What then? Will each specialist go about his own work ignoring or oblivious to all other requirements? Is the specialist in mental disorders forgetful that there is the nose specialist, the nerve specialist, and others?

While this is the age of specialization it is also the age of cooperation and the business of the world today needs cooperation. We are called upon to assume responsibilities along our chosen lines. We know what is needed along engineering lines, but isn't it reasonable to believe that we are not doing our best or that we we are not measuring up to our full opportunity unless we have called in specialists in other related lines, so that the final or complete development will have beauty—that beauty which has been defined as "certain properties of form resulting from the harmonious combination of diverse elements into a whole or into a unity?"

The past ten or fifteen years has seen the pendulum swing from the period where one master mind did everything in connection with a development to the other extreme where specialists worked independently and with complete oblivion to each other. In recent years those in charge are realizing more and more that there is more than each individual can know, resulting in this cooperation with others so that the result will be a unity, a harmonious whole.

While this highly specialized specialist is a victim of the times already referred to, it is an unnatural condition for in each of us there is some appreciation of beauty if it has not been purposely stifled.

It has been said that as a race we are slaves to tradition, that we are worshippers of precedent. If this is so, look at the background of the world's civilization and see what happened. Those monuments of engineering skill and architectural beauty which have endured the elements of time and the criticism of ages—who was responsible for them?

The last half of the fifteenth century there lived a great engineer, known in those days as a military engineer who was responsible for the work in irrigation, water control and harbor works, but this same master mind not only was an engineer of reputation but he painted "The Last Supper" and that much discussed picture "Mona Lisa". Leonardo De Vinci was a master engineer and he was a master painter.

Between 1475 and 1564 some of the greatest fortifications of Rome were built and during the same time a great building was built and stands todays as a great example of the civilization of those days. Michael Angelo was not only responsible

for the engineering work of his time but he designed the St. Peter's Church in Rome as well as painted several masterpieces.

Sir Christopher Wren, who lived from 1632-1723, designed St. Paul's Cathedral in London but planned the City of London after the fire and he was also an eminent engineer and a mathematician.

One of the great achievements of the ages was the building of the Coliseum at Rome in 80 A. D. A great structure 500 feet long, 300 feet wide and 120 feet high seating 87,000 people, a marvel in engineering skill and architectural interest. How many of the stadia built today will stand the test of time and the criticism of ages?

The Roman Viaduct at Nimes, claimed to be the grandest and most beautiful of all Roman works in foreign lands, was built by Agrippa, Governor of Nimes, under the direction of Emperor Augustus Caesar at the dawn of the Christian Era. Standing 161 feet above the bed of the river, designed as an aqueduct but having provision for service as a regular bridge, it not only is an engineering achievement but a thing of beauty.

The Bridge of the Seine, the oldest of the Paris bridges, stands as a beautiful monument of medieval France. Started during the reign of Henry III in 1578 but delayed because of war and not completed until 1607, it stands today as a representative of engineering triumph and architectural beauty and a monument to the theme of this paper that engineering and art can be combined into a unity.

The Appian Way, 360 miles long, was built in 313 B. C. Not only was engineering skill required but the entire route was lined with arches, monuments and other structures which were a part of this great Roman Artery. This highway is interesting in another sense in that it is said that Julius Caesar, the Curator in 65 B. C., built the first and only monument to a road contractor.

What was it that made these old masters design and build structures, which in spite of the passage of time and the so-called refinement of taste, still stand as works of strength and beauty? After all what is this aesthetic treatment of structures but an adornment of the actual construction, or a clothing or covering of the frame or structural elements?

The simplest example of this is taken from the Egyptians. Their form of construction was known as the post and lintel type—using the horizontal beam supported on columns or posts. While this was the construction required they decorated all this construction by painting or decorating. These people whom we think of as uncivilized were not content with strength and utility but they believed in beauty as well.

The Greeks in that age of architectural perfection merely decorated the structural features of the building. Taking the old form of pillow or bolster as used under the ends of two beams supported by a column, the Greeks merely decorated this bolster and made it pleasing in form and line while it served as a structural element.

Today—what of today with its gigantic structures, long span bridges, wireless towers, tall office buildings, high dams, and railroad viaducts. What is being done to make these interesting in appearance as well as safe structurally? While the general impression has gone out that the engineer is not interested in the beautiful and the architect is not interested in the engineering, yet some of the structures built in this country during recent years and now building have this combination of the useful with the beautiful.

The Tunkhannock Viaduct of the D. L. & W., 2,375 feet long and 240 feet high, is more than an engineering structure. Consider the offsets, the paneled piers and the moulded courses. This is a structure which makes an appeal to the public as well as being a great engineering achievement.

As I stood and looked at Hell Gate Bridge over the East River, New York, with its great arch span of 977 feet, 140 feet above the water, it made a great picture outlined against the sky. That master mind, Gustave Lindenthal, did not forget that this structure was to be seen as well as used and in the design of the piers, look at the thought and care that was given to make these attractive. As far as purpose is intended these piers could have been masses of plain concrete, unadorned, but look at the interesting treatment they were given.

The new bridge at Camden, New Jersey, not only required the efforts of a master bridge engineer but one of the greatest architectural designers of the country today was consulted with reference to the artistic or aesthetic design of this greatest of all structures.

As we roll along over our magnificent highways, those in charge are to be commended on the interesting touches to the

highway bridges. As far as purpose is intended, the railings and approaches could be plain, untreated surfaces, but some thought has been given to making these spots along the highways interesting. The brick panels, the moulded panels, the cap and base effect are attractive and add interest. These component parts of a railing have been made in proportion to height and width as they should be as the relation of the various heights of railings enters into the design just as the size of a man's hat is determined by the size of his head. As far as covering the head is concerned a hat three sizes too large would serve the purpose but the appearance demands a certain size.

Consider the highways with the vehicles served as a unit. Have the automobile engineers been content to house the engine in a rough, unattractive covering? Every detail is given care as to its purpose structurally and made beautiful, efficient in use, pleasing to the eye, and a joy to behold. A choice of two cars, each with the same engine but one unattractive in appearance, the other with beauty of design and pleasing outlines, which will you choose and which will the public choose?

The human race wears clothes primarily for protection. A gunny sack would serve this purpose, but can you imagine yourself ever being willing to use this type of clothing—never. We use color, we use the cut of the garment to enhance or beautify, but we don't stop there—we add certain adornments, entirely unnecessary as far as protection is concerned. How many of you would think of coming to this Short Course without a collar or necktie? We demand these colorful garments used by the people who ride over these highways, with the beautifully designed cars that are seen by the hundreds of thousands on these great white ribbons —but are we doing our part to add interest and charm to the things that we create?

The master minds of ages past have felt the need of beauty in engineering, the master minds of the great engineering projects today have felt the need of adorning their structures to make them more beautiful to look upon. Are you and I doing our part in this great movement?

The world needs engineers as it has never needed them before, the world needs beauty of line and form. You are the men who can give this refinement, this added touch to the engineering achievement of the age. It makes no difference whether it is highway work, bridge design, the building of water towers, power houses, or transmission lines. No one deplores more than I the promiscuous use of lace work, funeral wreaths and ornate decorations on a good many of our structures today.

Aesthetics in engineering means simplicity of design, refinement of detail, beauty of proportion, nothing more. This is one of the great needs of the day.

WATER SUPPLY FOR ARLINGTON COUNTY, VIRGINIA

The matter of obtaining a suitable public water supply for the Arlington and Washington districts of Arlington County, Va., has been receiving considerable attention recently. These two districts constitute the part of the county away from the immediate vicinity of Alexandria. Mr. H. A. Saffell, chairman of a committee representing local citizens' organizations, asked the advice of the Department of the Interior through its Geological Survey, as to the possibility of utilizing ground-water for this purpose. Such data as are available have been assembled and studied by Clyde P. Ross, one of the geologists of the survey. His report has been submitted to Mr. Saffel ,and a copy is on file in the office of the Geological Survey, where it may be consulted by anyone interested. The conclusions and recommendations are given below.

The communities near Alexandria are or can be supplied from the Alexandria city water system, which draws its water from a reservoir on Holmes Run. According to the census reports the Arlington and Washington districts together had a population of 4,517 in 1900, 7,559 in 1910, and 12,372 in 1920. The increase in population since 1920 has been rather rapid, and this growth may be expected to continue for some time to come. A public supply for these districts should therefore be large enough for at least 15,000 people, with possibilities of future expansion. The districts are almost exclusively residential. Most of the water would be used for domestic purposes alone and the average requirements per capita would be less than in most towns of similar population. A supply of a million gallons a day might be adequate for present needs, although it would not be liberal, especially during seasons when water is desired for gardens.

The whole country is underlain by crystalline rock, but in about two-thirds of the area this rock is mantled by sedimentary deposits, which increase in thickness southeastward and are thickest at Alexandria. There are in the Arlington and Washington districts numerous wells 30 feet or less in depth, but only a few have been drilled to depths of 100 feet or more. Consequently the data on ground-water conditions are somewhat scanty. In and near the city of Alexandria there are several deep wells that yield considerable water. The sedimentary formations there, however, have a much greater total thickness than they have in the Arlington and Washington districts. Also Alexandria is farther from the western border of the sedimentary rock and lies at a lower altitude than any place in those two districts. These factors all contribute to making ground-water conditions in the vicinity of Alexandria distinctly different from and more favorable than those in the Arlington and Washington districts.

Shallow wells are obviously unsuitable as sources of public water supply in Arlington County. They are subject to contamination by surface impurities, have small yields, and are in danger of depletion in periods of drought.

Wells more than 350 ft. in depth have been successfully drilled at Alexandria, where the sedimentary deposits overlying the crystalline rock are thick, but it is not advisable to drill to such a depth in the Arlington and Washington districts. A well 350 ft. deep in either district would penetrate at least 150 ft. of crystalline rock and in most localities much more than this. If an adequate supply of water is not encountered before a depth of 350 ft. is reached, the chance of finding it at greater depth would become progressively less. In general, crystalline rock at a depth of 350 ft. is likely to be too tight to yield much water. In many localities fissures or similar openings permit considerable water to reach depths of more than 350 ft. in such rock, but as a rule there is no way of determining the position of these openings in advance. If present at all they are likely to be few and far between, and such data as are available suggest that the chance of encountering openings of adequate size in the crystalline rock at depth in Arlington County is too small to warrant the expense of drilling.

At depths ranging from 50 ft. below the surface down to the lower limit of decomposition in the crystalline rock the prospect of finding a fair amount of good water is somewhat better. This is especially true where the cover of sedimentary material, consolidated or otherwise, is comparatively thick. The gravel and sand beds in the sedimentary formations of this vicinity are in general good water-bearers. The fractured and decomposed material at the top of the crystalline rock also contains water and will yield it fairly readily to wells. Where the crystalline rock is at or close to the surface the amount of porous material suitable to serve as a natural reservoir for the ground-water is comparatively small, and consequently the yield from wells is likely to be small. It is estimated that at favorable localities in the Arlington and Washington districts successful wells will most commonly be obtained at depths of 100 to 150 ft.

Probably no well drilled in the Arlington and Washington districts will yield much over 30 gals. a minute, and few will yield much over 15 gals. Wells in localities where the crystalline rock is close to the surface can not be expected to yield more than 10 gals. a minute, and most of them will yield less. In localities underlain by 50 ft. or more of sedimentary material wells drilled through this material into the soft upper part of the crystalline rock may yield from 10 to 20 gals. a minute. Where the well happens to penetrate clay with which only a small amount of material sufficiently porous to yield water is interbedded the amount of water obtained may be small. In most parts of the two districts this and similar unfavorable conditions can not be predicted from data obtainable at the surface. Consequently in drilling a number of wells a certain proportion of failures is to be expected.

The water in some existing wells is of poor quality, but as much the greater proportion of wells appear to yield good water it is probable that there would be no difficulty in getting water of sufficiently good quality. The danger of contamination is much less in fairly deep wells than in shallow wells, but the possibility of contamination should be constantly borne in mind.

The prospects of obtaining an adequate public water supply from wells do not appear altogether favorable. Enough water to supply the present population could probably be obtained from wells, but in order to get this quantity of wa-

ter it would be necessary to drill a large number of wells distributed throughout the area. An adequate supply for the two districts could probably not be obtained from wells put down at one locality. About 50 wells yielding an average of 15 gals. a minute each in groups of 5 or more would furnish a million gallons a day if they were kept in continuous operation. On account of unavoidable interruptions in operation, however, they would not furnish quite this amount. As some of the wells drilled would not yield as much as 15 gals. a minute and some would be failures or would yield too little to be economically pumped, it would doubtless be necessary to drill more than 50 wells in the near future. Moreover, a liberal allowance would have to be made for decline in yield due to continuous pumping and to exceptionally dry seasons. The cost of drilling 8-in. holes would probably not exceed $5 a foot, and the average cost of wells 100 to 150 ft. deep, equipped with casing, curbing, and electric pumps, would probably not exceed $1,000 each. Each well should be located not less than 100 ft. and preferably a greater distance from any other well and from any possible source of contamination. Each well would presumably be equipped with an automatic electric pump. The water from each group could be collected in a concrete reservoir and then pumped into an elevated tank, from which it could be distributed through the mains. The details of equipment for each group of wells would depend on their location. Probably most of them could be so placed that water would be distributed by gravity from a tank close to the wells. Before any large development based on ground water were undertaken it would be necessary to sink a number of exploratory wells and to subject them to prolonged pumping tests.

A system of water works utilizing surface water from Pimmit Run, Potomac River, or some other source would, if properly planned, doubtless be more adequate than any system using ground-water, because the supply would be sufficient to care for the growing needs of the county for a long time to come. The pumping machinery would be centralized in a few places instead of being scattered among numerous wells. On this account it would be possible to use efficient pumping machinery and to have close supervision by a competent man. There would not be the constant annoyance and expense of keeping in repair numerous small units, such as would be inevitable with a supply obtained from wells. Unless the water were obtained from the supply of the city of Washington, it would have to be either pumped against a considerable head from a point near the mouth of Pimmit Run or else piped a considerable distance from a source in the Blue Ridge. In either case a purification plant would be required.

Whether the water is obtained from surface or underground sources it is essential that the supply be reliable both as to quantity and quality. A technically trained superintendent would be essential for the surface water plant with its large pumps and more or less complicated purification system. If a ground-water system were installed it might be desirable to employ a similarly competent man to have general charge of all the groups of wells. One of the most important of his duties would be to see that a high standard of sanitation is maintained. The sanitary quality of the water in a well may be excellent when the well is drilled, but it may not remain so unless constant care is exercised.

The chief advantage of a supply from wells is the flexibility of the system. It would probably be wise to utilize surface water unless sufficient money were available for the construction of a large plant adequate to supply the entire area for some time to come. A system using ground-water could start with a few wells and be expanded as the need arose and available funds permitted. Consequently it would be possible for individual communities to equip themselves with plants adequate for their own needs if a plant large enough to supply the whole area of the Arlington and Washington districts could not be arranged for in the immediate future.

It is recommended that before the project of utilizing ground-water is definitely rejected, estimates be made of the cost of installation and operation of small systems of water works supplied by wells for the several communities, and that these estimates be compared with the estimates for a large unit system supplied by surface water. If the estimated costs of installation and operation of the ground-water units are not distinctly lower than those of a surface-water system, it will be the wiser policy to install the surface-water system. However, it is possible that a careful survey of the whole problem will show that it

will be more economical and feasible, until the population has considerably increased, to install a few small ground-water systems rather than to carry out the large surface-water project at present and to begin immediately to carry the heavy fixed and operating charges it would entail. If individual communities install ground-water systems the distributing mains should be so designed that as much of them as possible can be utilized if a surface water system is later installed.

It should be understood that the whole matter of obtaining water supplies from wells in this area is somewhat uncertain and that the ground-water conditions vary from place to place. Hence the first step in any plan to install a system of water works depending on wells must be the drilling of test wells to determine whether an adequate supply can actually be obtained. The wells so far drilled are not sufficient to afford this information.

MISSISSIPPI VALIDATES ALL ROAD DISTRICT BONDS

By Alden H. Little, of Little & Moore, Inc., St. Louis, Mo.

(Editor's Note: Mr. Little is Chairman of the Municipal Securities Committee of the Investment Bankers Association of America. The following article is from the Bulletin of the Association.)

When the Texas Road District opinion was handed down by the United States Supreme Court, on January 4, 1926, it was determined by eminent counsel that Road Districts in the State of Mississippi were organized in a manner quite similar to those in Texas. Inasmuch as the Mississippi Legislature was then in regular session, Honorable John C. Thomson immediately prepared a General Validating Act wherein it was provided that all road districts in that State were "validated, ratified and confirmed, and declared to be authorized by the Act of Legislature of the State of Mississippi." This bill was introduced in the Senate about January 17th, passed the Senate with but one adverse vote and was passed by the House with only two negative votes. The bill was signed by the Governor on February 13th.

This was a definite indication as to the temper of the Mississippi Legislature on the vitally important question of thoroughly protecting outstanding road district bonds of that State.

The real test came later, when approximately 415 special validating bills were introduced in the Legislature, were passed and signed by the Governor on March 11th last.

These bills are all similar in form and were prepared by Honorable John C. Thomson. In these bills, which are now laws of the State, every road district in Mississippi and its outstanding bonds were specifically "validated, ratified and confirmed," etc. The splendid work done by Mr. Thomson in preparing the form of these bills, was done gratuitously and our Association is again indebted to him.

From a letter just received from Mr. Thomson, I quote the following:

"It will be particularly instructive and heartening to the investor to find that Mississippi has stood so nobly behind its obligations and has so promptly acted to head off litigation and to forestall the possibility of defaults. I think that the State is entitled to the credit which will follow from the widest possible publicity concerning its action."

It was a very difficult task to secure an accurate list of all road districts in Mississippi which had bonds outstanding. On account of the shortness of the time available, it is barely possible that a few small districts were overlooked, although there is now no evidence thereof.

It should be borne in mind that the Texas decision only covered the Texas law. Mississippi might or might not have been affected thereby. In order, however, that nothing could possibly jeopardize the safety and standing of Mississippi Road District issues, the Legislature of that State made it very plain as to its attitude on the payment of just debts.

VALUATION OF ASPHALT ROADS IN SOUTH CAROLINA

Contributed by Robert G. Thomas.

Spartanburg County, South Carolina, enjoys the distinction of having the first completed road on the State System—an asphaltic road that after seven years shows no deterioration and is valued at considerably more than its cost. Under South Carolina law the paved highways taken over from the counties into the state highway system were given a valuation as of Jan. 1, 1925, and the counties are to be reimbursed on the basis of such valuation. Spartanburg County pavements constructed during 1917-1920 were

under this plan valued at more than $10,000 in excess of the original cost. A plain statement of Spartanburg County's experience makes a strong recommendation for asphaltic surfacing for highways.

On Jan. 1, 1925, valuation of some paved roads in South Carolina was made. These roads had been constructed at the expense of the several counties, aided by Federal funds. Upon being taken into the state system, estimates of their value on Jan. 1, 1925, were made for the purpose of reimbursing the counties.

Spartanburg County, having some miles of paved road that have been under traffic for more than six years, provides an opportunity for a showing.

Construction was started on 2.84 miles of road, beginning at the city limits of Spartansburg, S. C., in December, 1917, under the first contract made by the newly created State Highway Department. The base was of plain concrete, 20 ft. in width and 4 ins. in depth. The surface was of asphaltic concrete, "Topeka" type, 18½ ft. in width and 2 ins. thick.

The surfacing was completed in July, 1918, and has been under traffic for more than seven years on one of the most travelled routes in the state. The road was to Camp Wadsworth, and it is now on State Route No. 8, known as the "National Highway". The road is under state maintenance and the Federal highway engineer in his report of inspection on Oct. 9, 1924, stated: "At the time of this inspection the road was in splendid condition. Little or no maintenance has been required on the asphaltic surfacing."

On Jan. 1, 1925, in estimating the present value of the pavement for the purpose of reimbursing the county, the appraising engineers valued the 33,333 sq. yds. of base and surface at $2.15 per sq. yd., making $71,665.95 for the 2.84 miles of road. The original contract price was $1.67 per sq. yd., making $61,415 the cost of the road.

There was completed in September, 1919, a section of road measuring 1.83 miles from the city limits of Spartanburg on State Route No. 19, construction having been started in July, 1919. The base and surfacing were the same as in the preceding case and, on Jan. 1, 1925, the appraising engineer valued the 21,473 sq. yds. of base and surfacing at $2.25 per sq. yd., making $48,314.25 for the 1.83 miles of road. More than six years before, the original contract price had been the same.

There was another section of road, measuring 1.995 miles on State Route No. 19 from the city of Spartanburg, completed in July, 1920, construction having been started in August, 1919. The base and surfacing were the same as in the two sections before mentioned.

On Jan. 1, 1925, the 23,409 sq. yds. of base and surfacing were valued at $2.25 per sq. yd., making $52,570.25 for the two miles of road. The original price more than five years before had been the same.

The Federal highway engineer reported on Dec. 31, 1924, that "no maintenance necessary on surface of the 1.99 miles by the state. The contractor maintains surface for five years. The only maintenance by the contractor was repairs to one or two cracks. Shoulders were maintained by the state."

In regard to the other section he reported that on the 1.83 miles "no maintenance has been necessary on the surface, shoulders have had necessary repairs, and the ditches and drainage structures kept open."

A considerable mileage of asphalt road has been constructed in other counties of South Carolina within the past two years and is now under traffic. Their value, as determined on Jan. 1, 1925, is generally more than their cost. While higher prices on Jan. 1, 1925, for material and labor account in a measure for the favorable showing on these roads, the absence of any deterioration after as many as seven years of traffic is worthy of notice.

USING POWER CONSUMPTION TO MEASURE TRANSPORTATION COST

In an effort to prove conclusively that improved highways of the country have been built absolutely without cost to the land owner or the motorist, Dr. H. B. Shaw, Director of the Engineering Experiment Station of North Carolina State College is conducting some very interesting experiments in cooperation with the Problem Committee work of the Highway Research Board of the National Research Council and the North Carolina State Highway Commission. The complete results will be tabulated for the 1927 convention of the American Road Builders' Association.

Using the amount of power delivered to a motor vehicle from its power plant as the basis for computing the comparative cost of transportation over surfaced and

unsurfaced roads, Dr. Shaw expects to show the comparative cost of highway transportation over various types of road. The measurement of the amount of power used in driving a vehicle over a certain stretch of road is accomplished by registering the number of ampere hours of electricity consumed by the motors of a specially devised electrically driven truck. The comparative amount of power necessary to drive the truck over various types of pavement will be shown by the resulting figures.

"I believe that the amount of power consumed by a motor vehicle is the best unit for measuring the cost of highway transportation, Dr. Shaw said in explaining his experiments. "I believe the cost of traversing a number of miles of various surfaces will vary according to the amount of power used. This is taking into consideration the cost of gasoline, tires, depreciation, repair, etc. The experiments with the new truck, the third of its kind we have built for experimental purposes, will be carried on throughout the summer on many types of pavements ranging from the worst in mud holes to the finest of improved pavements."

The mechanism used in computing the amount of power used in driving a vehicle over a stretch of road consists of a truck chassis driven by two electric motors supplied with current from a large generator driven by an eight cylinder gasoline motor. The amount of electric energy to drive the truck over a stretch of road is measured on instruments registering the number of ampere hours of electricity consumed.

The experiments, according to Dr. Shaw, are expected to show the most economical type of pavement that can be laid. It will also prove conclusively, the director asserts, that improved roads have saved, by decreasing the cost of driving, to more than pay for themselves.

A complete report of the experiments will be rendered at the 1927 convention of the American Road Builders' Association.

IMPROVING 40,000 MILES OF ROAD ANNUALLY

The annual improvement of more than 40,000 miles of highways in the United States as a result of combined efforts of Federal, state and local agencies will continue during the next few years, in the opinion of Thomas H. MacDonald, Chief of the United States Bureau of Public Roads. During the past several years the mileage of improvements on our highways has exceeded that figure, he said.

Although Mr. MacDonald would not venture a prediction of the probable number of miles to be improved in the United States during the next few years, he expressed the belief that the proven economy of good roads will do much to influence an increase over the programs of preceding years.

In speaking of the present initial objective of the road building industry in the United States, Mr. MacDonald stressed the need for the immediate improvement of all roads included in the Federal-Aid and State highway systems by widening, surfacing, and elimination of danger points.

"In this manner," he said, "we can promote the best interest of the nation at large, both in the economy and the welfare of its industry. The increased traffic on our public highways has not only made their immediate improvement a matter of good policy for public convenience, but equally necessary to obtain the lowest possible cost of highway transportation."

NOTES ON HIGHWAY RESEARCH

By Prof. S. E. Steinberg, University of Maryland, Assistant Director Highway Research Board, National Research Council, Washington, D. C.

(Fourth of a series of radio addresses on this subject given from Station WCAP under auspices of National Research Council and Science Service.)

To many persons the word "research" implies something highly theoretical and without relation to the things that are practical. Actually, most of the advantages of a practical nature we now enjoy, from automobiles to radio, are the fruits of intensive study of underlying scientific principles which we designate as "research."

The great advances made in recent years in highway engineering are due to the research work undertaken by the federal government, through its Bureau of Public Roads, the state highway departments, the universities and industrial concerns interested in highway development. To make the results of highway research known to all agencies that might profit by their application is the function of the Highway Research Board which includes in its membership some of the most prominent scientists and engineers

interested in highway matters. The application of the results of these studies has made for a more economical expenditure of the billion dollars we have been spending annually for highway improvement during the past several years.

Highway engineers are treating the highway and the vehicle as a unit and are endeavoring to determine the wear of one upon the other, so that the roads may be designed to fit the vehicle. Likewise, automobile manufacturers are modifying vehicle design better to fit road conditions.

In order properly to design a road, the total cost of highway transportation must be considered. This cost consists of two parts: first, that of the road itself which is paid for by the public, and second, the cost of operation of the vehicle, paid for by the owner. The cost of vehicle operation includes such items as depreciation, repairs, gas, oil, and tires, each of which is directly affected by the kind of road surface traveled.

Since tires are an important item in the cost of motor vehicle operation, researches are under way to determine the relative effect of different road surfaces upon tire wear. In these tests, both cord and balloon tires are used at the inflation recommended by the manufacturers. The car is run up and down selected level stretches of different road types until the vehicle has covered a distance of 500 miles, after which the wear of the tires is determined. Thus far it has been found that the tires wear the least on concrete and brick roads, the loss in weight of each tire on these surfaces being about one ounce for a 500 mile run. The tire wear on gravel roads is found to be from 2 to 7 times that on concrete or brick, while that on macadam varies from 10 to 50 times the wear on concrete or brick, depending upon the condition of the surface.

The results also prove that front tires wear less than rear tires, the amounts being 50 percent to 75 percent less. The relatively greater wear on rear tires is due to the bounding and spring of the rear wheels when traveling over rough surfaces. Experiments also show that when we start our cars from rest the rear wheels exert a downward kick on the pavement, ranging from 100 pounds to as much as one-half a ton. This blow must be resisted by the rear wheels and axle every time the vehicle is started from rest.

Other investigations are being conducted to determine the relative consumption of gasoline and oil on different types of roads. As a result of these studies, it has been found that the increased consumption of gasoline required to travel by ordinary dirt roads costs the motorist as much as if he had to pay an additional tax of 24c a gallon gasoline. Even good gravel roads impose an additional expenditure equivalent to a 9c tax. Compared with the tax imposed by bad roads, the gas tax paid for highway improvement is truly insignificant.

To determine all the elements of the resistance to motion offered by road surfaces, and the resulting wear upon the vehicle, it is necessary to know the effect of the wind on a car. Due to their variability, the natural winds could not be used in experiments to determine this element of atmospheric resistance. Consequently, a wind tunnel large enough to test full sized cars was designed and built. Artificial wind velocities, ranging from 10 to 40 miles an hour, are produced in the tunnel with fans driven by electric motors. Thus far a number of standard makes of automobiles, including the different types of bodies, have been tested in the tunnel, and the wind resistance, as well as the horsepower required to overcome it, has been determined for each type of car at varying speeds. The results show that when you drive at 35 miles an hour you use, on the average, 8 horsepower to overcome wind resistance. If you reduce your speed to 25 miles an hour you save 5 horsepower.

Considerable attention is being given to determining the cause of cracking in concrete roads. The extent of cracks in a slab is dependent upon the underlying soil, the quality of the concrete, and the loads the pavement must bear. When a vehicle passes over a concrete pavement, the slab is deflected. The result is that under traffic the road is subjected to a wave action, the slab rising and falling with each passage of a wheel. On roads under heavy traffic at high speeds, this motion may be repeated many hundred times an hour.

Experiments have been conducted in the laboratory simulating these field conditions, with the discovery that concrete is subject to fatigue, which, in many respects, is analogous to muscular fatigue in human beings. After continued rapid application of load, the normal elastic properties of the concrete are overcome and the fatigue limit is reached. The result is a break in the concrete and the ap-

pearance of a crack in the road. The analogy to muscular fatigue is further evidenced by the fact that if before failure the concrete is permitted to have long periods of rest, it recovers its ability to resist the applied forces and the fatigue limit, or life of the slab, is extended.

The stresses produced in roads by traffic, as well as the deflections and changes of length they cause, are measured by specially constructed instruments installed in the road. An analysis of these measurements serves to determine the proper thickness of the road slab in its different parts to support the traffic the road must carry.

As a result of research, there has recently been introduced a new kind of cement, which, when used in concrete, has the property of developing greater strength in 24 hours than is developed by the ordinary Portland cement in 28 days. This opens up remarkable possibilities in road construction. Whereas, by use of the ordinary cement a road must "cure," or acquire strength, for 14 days after being laid, during which time it is not permitted to carry traffic, it may now be possible to build a portion of a concrete road on one day and open it to traffic the next. Studies are under way to determine more fully the physical properties and characteristics of this cement.

Statistics show that of the 26 million motor vehicles in the world, we in the United States own about 80 per cent. They further indicate that 60 per cent of our 20 million vehicles are owned in cities. Traffic counts have revealed that at time of peak loads on certain highways near large cities cars travel past a given point at the rate of 1,600 to 2,000 vehicles per hour. Due to traffic congestion on rural roads, super-highways are under construction or being planned in many sections of the country. These provide for four or more lanes of traffic moving abreast, permitting slow and fast traffic to sort itself, and thereby increasing the capacity and safety of the highway. Future developments may also make it necessary to provide separate highways for freight and for passenger vehicles. It is hoped that the superhighways will restore the pleasure once realized by city dwellers in riding on the main rural roads on Sundays and holidays.

Many persons are of the opinion that most highway accidents occur at grade crossings, or on sharp curves in the road. It may surprise some to learn that a good majority of the accidents occur on straight roads. The explanation is that even careless drivers exercise some degree of caution at crossings and curves, while the straight smooth stretch of road serves as an incentive to most drivers to speed and to pass vehicles traveling at a slower pace.

As highway transportation develops the problems that confront the highway engineer increase in number and complexity. Basing his solutions upon the foundation of scientific research, the engineer may face future developments with confidence; for research makes evident the wastefulness of the pioneer, and points the way to economy.

WATER WORKS IMPROVEMENTS AT BOONVILLE, IND.

By Charles Brossman, Consulting Engineer, Merchants Bank Bldg., Indianapolis, Ind.

(A paper read at 1926 meeting of Indiana Section of American Water Works Association.)

The Boonville water works plant was built in 1896 by the Boonville Water Works Company and leased to the Town, the Town taking $10,000 worth of stock. The population at that time was given as 1,900 inhabitants. The plant was put into operation in August, 1896. The engineer was A. H. Kennedy, Rockport; contractor, Frank Shefeld, New Albany; the franchise was for a term of 20 years and provided for the future purchase of the the works by the city.

The original pump was a McGowan duplex steam pump; capacity 1,000,000 gals. per day; approximately five miles of pipe line were installed. At that time there were 35 fire hydrants.

The original cost of the plant is given as $31,000. The source of supply was an artificial reservoir and water from this was pumped to a 100,000 gal. tank.

Since 1986 when the population was 1,900, there has been an increase to approximately 5,000 inhabitants, with water consumption at the present time given at from 250,000 to 300,000 gals. per day, which would be in the neighborhood of 60 gals. per capita.

The present water supply is taken from two lakes or ponds. No. 1 lake is about 2,300 ft. from the pumping station and capacity is given as 34,000,000 gals. No. 2 lake is about 7,500 ft. from the pumping station and its capacity is given as 40,000,000 gals. There is about 2,300 ft. of 10 in. line from lake No. 1 to the pump-

ing station, and about 4,000 ft. of 8-in. line between lake No. 1 and lake No. 2.

The standpipe is of 100,000 gals. capacity—85 ft. high to the balcony, 112 ft. to the top; the tank is 30 ft. diameter by 27 ft high with a hemispherical bottom having a 5 foot drop, making the total height of the tank 32 ft.

The present pump equipment consists of one duplex steam-driven pump and one Dayton-Dowd electric driven centrifugal pump, which pump is located in the electric light plant. Estimated water pumped is 90,000,000 gals. per year, or 250,000 gals. per day; but for estimating purposes we are using 300,000 gals. per day.

At the present time the mains are given as follows:

LIST OF MAINS.

10-in. diameter	3,625 ft.
8 in. diameter	1,505 ft.
6-in. diameter	28,948 ft.
4-in. diameter	18,824 ft.
2-in. diameter	1,382 ft.
1½-in. diameter	1,610 ft.
1-in. diameter	3,000 ft.
Total	58,892 ft.

There are 1,063 ¾ in. services; three fountains and troughs. There are 74 4-in. fire hydrants. The pressure at the pumping station is approximately 80 to 85 lbs.

From the above it will seem that since the original water works plant has been put in there has been considerable growth and that the mains and hydrants have more than doubled.

An examination of the water works reservoirs and drainage area shows both are sufficient. The drainage area, especially, being very small, has been the cause of scarcity of water from time to time, and especially in times of extreme drouth which occur in periods of about 30 years, as shown by a study of rainfall conditions.

The present water is a direct surface water and the only treatment it receives is chlorine treatment, which, with the character of water available, does not make a proper and safe drinking water. In addition to being surface water pond No. 2 received considerable mine drainage which makes the water unfit for use.

Rainfall

Considering any local water supply, it is necessary to know the amount of rainfall, as water obtained must originally be derived from the rainfall of that region. Especially is this true and more affected by local conditions where impounding reservoirs or well waters are used. There are no large streams near Boonville except the Ohio river, which is considered under a separate heading.

There are no available records of rainfall for any period of years for Boonville, Indiana, so it has been necessary to use records of rainfall in nearby places, and in estimating the rainfall in this region, we have found the rainfall for Evansville, Bloomington and Huntingburg, as far back as the year 1887, and up to the present year. As these cities are close, these figures are used as a basis for estimating the rainfall at Boonville. The monthly precipitation is tabulated for each month from 1887 to 1923, which gives a period of 36 years.

A chart was made showing graphically the annual rainfall for Evansville, Bloomington and Huntingburg from 1887 up to 1923, from which an average was estimated for Boonville. These are important and, from the fact that they extend over a great length of time and show a close average as to amounts, are proof they are conservative for use at Boonville.

Considering the minimum amount of rainfall over an extended period, we have preferred to use the records from Bloomington for the reason that it more nearly approaches conditions at Boonville.

With the above information on rainfall, also the available records of water gaugings of the East fork of White river, it is possible to have a reasonably safe index of the hydrology of this section of Indiana that can be applied for Boonville. We are, of course, more interested in the minimum years than the averages or maximums.

As long term measurements of run-off are usually not available, it is of course necessary to use limited data of run-off in order to determine or calculate the percentage the run-off is to the rainfall and from this to construct assumed run-off figures for the periods where records of rainfall are obtainable. The records of the East fork of White River at Shoals, Indiana, are available from 1903 to 1917. There is a drainage area of approximately 5,000 square miles above the gauging station and estimated run-off factors have been figured and used as of this region.

Examination of the rainfall chart shows the three dry years for Bloomington occurred in 1899, 1900 and 1901. This represents the minimum rainfall which may be expected to occur once over a

long period of years, which in this case would be about 30 years, and it is believed this would be the conservative rainfall to use. The minimum rainfall in these years was as follows:

1899	34.8 ins.
1900	37.8 ins.
1901	33.1 ins.

The estimated run-off factors used for a period of dry years give an annual run-off as follows:

1899	26 percent
1900	22 percent
1901	23 percent

For evaporation on water surfaces the nearest records are those in Indianapolis and they have been used in making the estimates, the total yearly evaporation being in the neighborhood of 48 ins.

With this information at hand the mass diagrams for storage, etc., were made and charts showing the total accumulative yield and capacity for three dry years, and calculations were then made showing the storage capacity required.

Population

It is necessary to make an approximate forecast on population to determine the future consumption of water.

The population of Boonville in 1896 was 1900, in 1920 it was 4,450, in January 1925, about 5,000. Based on the above a curve was plotted which shows an approximate population of 10,000 in 1950.

The present water consumption shows about 300,000 per day or about 60 gals. per capita. This is expected to increase somewhat with the new water due to its being much better than the old supply. In 1940 it is expected the consumption will be 720,000 gals. per day; in 1950, 900,000 gals. per day. It is also expected by 1940 the consumption will increase from the present figure of 60 gals. per capita to 90 gals. or higher.

Sources of Supply Investigated

A number of available supplies were investigated; the first being the Squaw Creek site, being about 7 miles northwest of Boonville. This contemplated construction of a dam approximately 20 ft. high. The drainage area on this site was approximately 10 sq. miles.

In this same location a dam 15 ft. high was also considered.

The cost of this location including pipe lines and with a 20 ft. dam and all other work, was $397,000 which also included a filtration plant.

The cost for a 15-ft. dam, same as above was $363,000.

The third scheme, at Cypress Creek, located 4½ miles south of Boonville, shows an estimated cost of $327,000, including filtration plant. However, this location had only 1¾ miles of drainage area. The location for the dam was good, but for lack of sufficient supply, this could not be seriously considered.

A location on Little Pigeon Creek at a point about six miles southeast of town was considered. Little Pigeon Creek at this point has a drainage area of 15 square miles, but this would have meant an estimated cost of $242,000, not including the construction of a dam, which would probably have been necessary as the dry weather flow in the creek would not have been sufficient without storage.

Of course the Ohio river was not to be slighted, as here was an unlimited supply of water, although the nearest available point was about ten miles south of Boonville. This situation was also investigated and it was found the total cost of this would be approximately $520,000, and the pumping charge would have been very high, due to the lift and friction in lines. All the above locations would have required filtration plants which increased the total cost and also the pumping cost.

In cities of this size it is always desirable to consider every suitable and sufficient supply available. In the case of Boonville the omission of a filtration plant and its attendant operation was of considerable importance, as in any scheme to be considered in this case, the overhead and operating charges would necessarily be high for a city of this size, therefore a careful investigation of subterranean supplies was considered.

As usual, there is always someone who has an ulimited supply near town, and Boonville was not the exception. Five or six holes were drilled to satisfy the sponsors of these locations and resulted in wells suitable for only farm purposes or gave dry holes. At these particular locations the geological and topographical conditions pointed to scarcity of water.

Other well supplies were considered southeast of Boonville in what is known as the lake drain region, which was thoroughly investigated, starting with surface investigations, as well as geological and topographical investigations, and later actual drillings through this district. This lake drain region was found to give every indication of an unlimited supply for the City of Boonville and an estimate on this

showed a cost of $290,000 for one scheme and $217,475 for an alternate scheme. The first scheme contemplated pumping direct from the wells to the water tower at Boonville. The second scheme on the lake drain region contemplated one pump at the well site, pumping to the reservoir at Boonville, and then a second pumping to the elevated tank. This latter system was finally adopted, as not only the best, but the least in cost, the most flexible and better suited all around for the conditions at Boonville.

A description of the lake drain region is of interest as it is somewhat unusual. What is known as the lake drain region is a drainage ditch running through to Pigeon Creek. This covers a very large area, being about twelve and one-half square miles tributary to the main part of the lake drain with a greater area than this towards the south, with over double this amount of drainage area in the entire region. Investigation below the surface revealed sand layers varying in depth from several feet of sand and gravel along Pigeon Creek which increased from 100 to 150 ft. in depth towards the south. A careful study of this region shows a line of drift along the Ohio River valley more or less parallel to the river and running as far back as six miles from the river.

The drift line is roughly defined on the U. S. Geological Survey records, but it actually extends further back than they show by the surveys.

In our investigation we found there had been drillings for oil in this region a number of years back. There was a slight flow from this old oil well. One of the parties originally interested in this stated they were quite sure up to 155 ft. was sand and gravel, and after this they encountered sand stone and three or four hundred feet down they struck a vein of water which flowed over the top. At present there is a small stream of salt water running from the well.

We found the original drillings of this well still on the ground and calculations of the mound would show that possibly over a 100 ft. of gravel had been taken running from this well.

Other investigations and out-croppings showed the same result with the depth decreasing towards Pigeon Creek. The lake drain ditch flows about 10 or 12 ft. below the grade line and investigation along this ditch showed seepage of water from the gravel into the ditch. Water for domestic use was easily secured by the farmers in this entire region.

We therefore reached the conclusion this large area known as lake drain had at some time formerly, been subject to deposit from the drift of the Ohio river, and while it may not have been termed an old river bed, it had every indication of having been subject to some flow and back water from the river, or had been a lake adjacent to the river that had finally filled up from the river overflow. This is not a glacial region and river drift is the only way to account for the sand and gravel at this point.

With all these indications it was therefore recommended to obtain a source of supply in the lake drain region. After this the city drilled a number of test wells in this region; the first in the neighborhood of Bullecktown and later further into the lake drain region where the present wells are located. All of these showed gravel from the start, gradually increasing in depth as the lake region was penetrated.

The present wells are located at a point where the water bearing gravel is approximately 25 to 28 ft. deep and stopping at the sand stone about 50 ft. below ground.

The formation varied considerably; in some of these wells were layers of fine sand not much over a foot in depth varying with coarse gravel, showing these had been deposited in successive layers or waves. In some of these wells were found very coarse deposits of gravel to a depth of 16 ft., and then a considerable layer of finer sand, so this region showed there had been a fair velocity of water at first and later a very low velocity which deposited the very fine sand indicating a receding of the water between successive inundations.

After the test wells were drilled contract was let for two 16-in. wells, both of which were approximately 50 ft. deep and having 18 ft. of Cook strainer 15 ins. in diameter. The strainers were not slotted until after drilling, and then were slotted to suit the kind of gravel found. In the case of the coarse gravel, the slots were made large enough to take out all fine sand, but where deposit showed fine sand only, the fine screen was used.

Due to simplicity it was desired to use centrifugal pumps if possible, especially at the lake drain region and in running the tests on the first well it was found the static head of water was approximately 12 ft. below the ground and when pumping around 300 gals. per minute the

water drew down approximately 26 ft. below ground. It is the intention to place these pumps in a pit about 10 ft. below ground which would give an approximate lift of 15 ft. at 300 gals., or around 20 ft. at 800 gals. This was determined by taking the draw down under different conditions. Actual pumping at around 700 gals. a minute showed a vacuum of 25 ins. at the pump, therefore each 16-in. well was reinforced with a 10-in. well placed about 300 ft. away and running a 6-in. suction line from this well to the main pump suction. The actual test at 800 gals. with these two wells showed a vacuum of 16 in. on the gauge so the two wells to each unit should give an ample capacity for the pumps. Of course with the 600-gal. per minute pump, the draw down would not be as much.

It was decided to use two pumping stations in this region; each pump has a 16-in. well and an auxiliary 10-in. well. The main pump is a 4 stage 250 ft. head 800 G. P. M., capacity with a 75 H. P. motor on one end, a 90 H. P. Sterling gasoline engine opposite. The other pump is a 600 G. P. M., and consists of a two stage pump at 160 ft. head, and on the same shaft with a jaw clutch an additional single stage pump at 90 ft. head. The two pumps can be placed in series, giving 600 gals. a minute at 250 ft., or by throwing out the end pump 600 gals. a minute at 160 ft.

The same scheme is followed in the pump house located in the City of Boonville at which point there is a 800 G. P. M. pump with gasoline engine and motor, good for 250 ft. head; also a motor driven pump, one pump being two stage for 185 ft. head and the second pump on the same shaft being a single stage pump good for 65 ft. head, giving a total of 250 ft. head when this unit was placed in series.

This arrangement is somewhat unusual, but it will be found that in going over this scheme it is very flexible and this arrangement was made not only for flexibility but for economy.

In any water works system there are two factors to consider as far as quantity of water is concerned; one is for domestic consumption and one is fire consumption. It is often hard to reconcile the two, and centrifugal pumps with long pipe lines sometimes present very complex problems if real economy is to be obtained, hence the reason for this combination at Boonville.

With the new 1,500,000 gal. reservoir and 100,000 gal. stand pipe, the Fire Inspection Bureau desired a capacity of not less than 1,400 gals. per minute for fire pumping, taking into consideration the storage capacity and reservoir. It will, of course, be a long time before Boonville will require 1,400 gals. per minute for domestic consumption. This, of course, would mean only three hours pumping for the present supply, but it would require a very heavy electric demand and large size motor.

Since 1,400 gals. is the minimum, the pumps were designed to take care of necessary static and friction head when pumping at this rate, if one pump were operated designed for this total friction, due to the characteristics of centrifugal pumps, there is a large drop in friction head and a corresponding loss in economy due to the changed condition. It was found a 600 G. P. M. pump of two stages could be very easily used and with good economy for ordinary pumping, pumping from the two stage pump at the reservoir or if fire demand came up and both pumps were thrown in, then a 600 G. P. M. pump would be placed in series and would be good for a total head of 250 ft. This would be operated in this manner with the 800 G. P. M. pump. When these two pumps were in operation the total head would be in the neighborhood of 250 ft. However, in domestic pumping using the 600 G. P. M. pump, due to the difference in friction the head would only be about 160 ft. when using the one pump.

In addition to this the combination 600 G. P. M. pump at the lake drain can be placed in series for 250 ft. head and by-pass around the reservoir, thereby pumping direct from the lake region into the elevated water tank. Likewise at the city pumping station for ordinary consumption, 600 G. P. M. with single and double stage can be used, and in case of fire, can be placed in series. The 600 G. P. M. will run in connection with the 800 G. P. M. the two giving 1,400 gals. per minute at 250 ft. head.

This gives a very fine arrangement as to flexibility and also allows a good economy when pumping domestic supply, at the same time giving a system meeting either the fire requirements or increased consumption due to growth. Space is left in each pump house for future pumps.

Each well is equipped with a Cook foot valve placed below the water line of the well, and while there is a check valve in the discharge line of the pumps, there is also a by-pass around the check so a

small line would always feed around the check and keep the pump primed in case of slight leakage through the foot valve.

These pumping units are operated with General Electric Synchronous motors with direct connected exciters. The pumps are designed to give approximately full load on the motors, and when operating at the designed pressure they are practically at full load. The motors are 2,300 volt 3 phase 60 cycle using primary current, which with the synchronous motors give the lowest possible electric rate.

It is the intention that the lake drain stations will be operated by a farmer living across the road from the pumping site, as the operation is comparatively simple. One pump in each case is equipped with Sterling gasoline motor, in case there be interruption of power service.

In the city the pumping station also is similarly equipped, using a 2,300 volt synchronous motor with gasoline engine reserve. The old water works had the pump located in the electric light company's plant in order to save cost of attendant. To carry out this same idea a new fire station was built which houses the fire truck for the fire department. This station also had a 5 room dwelling upstairs for the attendant, and in the rear is located the pumping plant and work shop. No extra attendant is required for this operation.

The financing of this work is of interest. Almost a year elapsed after the report and recommendations were made on this work and the wells were drilled; then it was found the water in the old reservoirs was getting low. Mr. Thomas Mullin, mayor, realized the importance of pushing this work and a movement was started at once to raise sufficient money to build the new pipe line. Bids were taken on pipe and centrifugal cast pipe was selected, it being approximately six miles from the lake drain site to the location of the reservoir. It was realized something would have to be done to get this work started and a meeting was called by the mayor, Mr. Mullin, calling in the three banks of Boonville and the situation was put squarely before them to raise enough money for letting the contract on pipe and laying. This money was subscribed for within a few hours, each bank promising to take its portion. Contracts were let for pipe and laying and with a water shortage staring the city in the face, Mr. E. E. Hartig of Evansville took the contract to lay five and one-half miles of pipe in forty days. Work was started at once, and contracts were let for the first pump house and one pump and the work pushed rapidly. As the lakes at Boonville became lower, the pipe line crept closer to Boonville, and anticipating the day when the pipe line would be finished the town set July 28th as the day for opening the valve and putting water into the old lake. The water in the lake was being used up so fast, that a temporary pipe line was laid from a pond from one of the mines some distance away—6 in. pipe was hauled in from Owensboro, Ky., where the old private plant was being dismantled. This pipe was laid on the ground and a small gasoline pump unit was placed at the pond. Water pumped over the hill flowed into a ditch which finally reached the old Boonville reservoir. Even this did not help very much and by the date the pipe line was completed up to the old reservoir the water in the reservoir had practically reached the bottom, although restrictions had been placed on the supply.

On the day set for inaugurating the new water works, a large part of the population of Boonville was on hand to see the opening of the valve.

The ceremonies were started when a large black hearse, bedecked with plumes and hauled by a team of black horses carried a large coffin in which was the body of "Old Man Water Shortage". In a little mound near the old lake with six willing pallbearers, who were far from being mourners, the body of "Old Man Water Shortage" was lowered slowly and reverently in the grave. This was the only tinge of sadness to the celebration, unless it was the pitifully small supply of water in the old reservoir before the new supply was turned on.

The new pump had been in operation for several hours and as soon as the services were over the crowd repaired to the scene of the opening of the valve which was turned on by Mayor Mullins. With the pumps under high pressure, a large amount of air in the new pipe line burst forth with the water, and spectators were drenched and baptized with the new water supply.

It is now believed the water troubles of Boonville are over for all time as there is at least 30 to 40 square miles of water bearing strata in the lake drain region, and should the city continue to grow the supply line can be extended and new pumping stations added as the consumption increases. However, a simple calcu-

lation will show that the area around the present pumping stations will suffice for a long time to come as the supply in this region is fully adequate to meet the demands for the future.

Boonville is an example of what can be accomplished when necessity arises, as the usual procedure in such towns and cities is to keep putting off, but when the city found they had to do something or have no water, the money was raised within a few hours under two separate subscriptions. After the plant was built and something tangible at hand the matter of selling the bonds for this project was not so difficult.

Another example is, that what Boonville has gone through shows the futility and error of adopting inadequate supplies, which are fundamentally wrong. With what it cost to build the first two reservoirs in Boonville, a pipe line laid 30 years ago could have been built at the lake drain region for little more than what was expended at that time.

Reservoir

The new reservoir consists of a circular concrete reservoir with mushroom type columns top and bottom. This reservoir is 125 ft. in diameter and 18 ft. deep and floors are 10 ins. thick and the roof is 6½ ins., both reinforced three different directions. The walls are 16 ins. thick with a double row of reinforcing. The reinforcing bars were held in position on steel chairs or supports which were welded to 4 in. channels. These chairs held the steel in proper position while the concrete was being placed. The floor was built first, then the walls, then the columns and the roof.

A joint was left throughout the entire junction of wall and floor; this joint being ½ in. by 6 ins. deep. This was later poured with asphalt and caulked with oakum in alternate layers. In addition to this, to provide against leakage an 8-in. galvanized crimped iron strip was placed half in the floor and half in the wall to provide against any possibility of leakage. On top of the roof was placed a reinforced concrete aerator house, having cast iron baffles set on an incline of about 30 degrees. The water from the lake drain being discharged over this and being thoroughly aerated before falling into the reservoir. The reservoir was also arranged to by-pass the water direct to the city pumping station.

This reservoir was built by the Roth Construction Co., of Boonville, Ind.

The strainers used on the wells were made by A. D. Cook. They were 15-in. strainers and were slotted to suit the gravel and the length of strainer was approximately 18 ft., and where the coarse gravel was found a No. 80 to 100 slot was used and where the fine sand was found the slots were as small as No. 14.

The pumping units used were Dean-Hill four stage pump for the 800 G. P. M. units with G. E. 75 H. P., 2,300 volt motors and four cylinder 90 H. P. Sterling Engine for the alternate drive. The 600 G. P .M. pumps were of the same make except the two stages were separate from the last stage. This last stage could be cut in by a jaw clutch. This pump was driven by a 60 H. P. General Electric Syn. motor.

The pipe was furnished by the American Cast Iron Pipe Company using a de-Lavaud Centrifugal cast pipe with lead joints.

The pipe line was laid by Emil Hartig of Evansville, being laid in less than 40 days.

The entire work was designed in the office of Charles Brossman. Mr. George T. Gilbert was resident engineer on the construction work. Mr. C. C. Abbott, City Engineer, assisted in surveys and also took charge of some of the installation work which was done by day labor. The cost of the entire plant was approximately $225,000.

SAN FRANCISCO TO TRY THE "STAGGER PLAN"

(Editor's Note: The following article was published as an editorial in the San Francisco Municipal Journal for April 8, 1926.)

One of the greatest problems that confront cities today is congestion on the street cars in the crowded hours, morning, noon and evening. This not only causes delay and loss of time to the hundreds of thousands going and coming to and from their homes and places of work, business and amusement, but is demanding consideration in some cities from the standpoint of health. These crowded hours are due, of course, to the fact that the stores, offices, factories and places of amusement open and close at the same hour. In a city the size of San Francisco this throws hundreds of thousands of passengers upon our street cars at the same time. Added to this, thousands of automobiles carrying individual passengers crowd into the down town streets and by blockading each other and ob-

structing the street car systems, add greatly to the confusion and inconvenience to the traffic of the rush hours. It is impossible, of course, for any company in any city to prevent this crowding.

The matter is receiving serious consideration in the large eastern cities. The Civic League of Improvement Clubs is engaged upon a method which has proven successful elsewhere and is receiving attention in New York and other large eastern cities. It is called the "Stagger Plan." It will add no expense to either taxpayers or the traveling public. The City Planning and Traffic commitees of the Civic League, after investigating this congestion and gathering information from the large cities throughout the country, made its report to the board of governors at their meeting held last Tuesday. The report was in part as follows:

"A system of 'staggering' the hours of opening and closing different lines of commercial and industrial activities is proposed which it is hoped will bring about a relief from the acute congestion existing, by spreading the peak loads over an hour-and-a half to two hours in the morning and over a similar period in the afternoon.

"In line with this proposal it is suggested that miscellaneous establishments advance their hour of beginning, especially in the heavy working hours by one hour.

"The street cars carrying these workers will then be released in time for the transportation into town of employes of other establishments whose working hours remain as they are.

"Likewise, automobiles carrying men to these establishments will then be off the streets in time to make room for other vehicles carrying their passengers into town.

"Food product establishments, jobbers and delivery systems could advance their hours with great advantage to themselves and added convenience to consumers.

"Retail stores could readily open an hour later in the morning without any great inconvenience to any one, and by remaining open for a similar period in the afternoon would enable many other employes to make their purchases after working hours. This would add materially to efficiency, especially among female employes in offices, etc., who could then devote their full time to their employment and yet have ample time after hours to do their shopping.

"Banks, bond and brokerage houses, by advancing their hours, would likewise be placed in better position to keep in touch with their eastern connections, and by the earlier closing thus brought about enable their managers and staffs to enjoy a much-needed game of golf before dinner."

The committees recommended to the board that an invitation be sent out to commercial, industrial and transportation organizations to attend conferences in traffic conditions in the rush hours in this city, with the ultimate purpose of working out a practical and feasible method for putting into effect the "Stagger Plan."

The board of governors adopted the report of the committees and directed them, together with the transportation committee, to bring about these conferences and to work out a mutually agreeable, practical way of putting into effect the "Stagger Plan." It is hoped that this plan will furnish the much-needed relief in the crowded hours, and a solution of a problem which it seems impossible to solve otherwise.

GREATER SAFETY AT RAILROAD HIGHWAY CROSSINGS

By Charles E. Hill, General Safety Agent, New York Central Lines

(A paper read at the 12th Annual Road School at Purdue University, Lafayette, Ind., Jan. 18-22, 1926.)

In discussing safety regulations at railroad highway crossings we must do so from a broad standpoint, having in mind not only the problem with which we are confronted today but must take into consideration the conditions we may reasonably expect to exist in the future. This subject is a vital one and is of tremendous importance in any plan we may adopt in our efforts to reduce accidents at railroad highway crossings.

We must approach this subject from a national viewpoint for it has, indeed, become a national problem, one which has perhaps created more discussions than any other question in which the railroads of this country and the public are mutually concerned. While the crossing accident problem is but one of the many types of problems with which the railroads have to contend it is no less important and today is being given greater consideration by the carriers than ever before.

Before entering into a specific discussion of this subject, in order that you

may possibly have a wider vision of the accident situation in its entirety, we will broaden out and take a retrospective view of the entire accident field, for we find that one of the outstanding problems of our country today is the frequency of accidents, it matters not from which angle you may view it. The enormous loss of life, due to accidents, as a result of a lack of carefulness on the part of our citizens in appalling, as is evidenced by the fact that last year in the United States as a result of accidents of all kinds, of which those occurring on the railroads were only a part, there was a daily casualty toll of 250 deaths and 6,000 injuries. This can all the more be appreciated when you know that during the recent war, with two million of our men at the front, the daily casualty toll to our soldiers was 100 killed and 220 wounded. The ravages of war take their toll in large numbers, but the ravages of carelessness take toll in even greater numbers, for as serious as the casualties resulting from war were they were only one-twentieth as great as those occasioned to our citizens through accident while engaged in peaceful occupation.

To What Extent are Crossing Accidents Contributing to Our National Casualty Record?

During the 7 year period from 1917 to 1923, inclusive, as a result of crossing accidents in the United States there were a yearly average of 1,882 deaths and 5,100 injuries, and during 1924 there were 2,149 persons killed and 6,525 injured in this manner, an average of 24 casualties per day, as compared with 9 per day 12 years ago, an increase of 167 percent, which is not in harmony with the increase in the population of our country during the same period, which is only 15 percent.

We must not overlook the fact that casualties resulting from crossing accidents are not confined to the user of the highway, for in 1922 there were 27 derailments of trains due to accidents of this character causing death and injury to 138 railroad employes and passengers, saying nothing of a tremendous loss of property.

The Physical Situation

We had in the United States, Dec. 31, 1924, 242,807 crossings at grade. In seeking a remedy we must do so upon the theory that the future holds no panacea in so far as the physical situation is concerned, for it has already become an acknowledged fact that a solution of this problem, through crossing elimination, is unthinkable by reason of the prohibitive expense, which is conservatively estimated at 20 billion dollars, and the time required to perform such a stupendous task—20 billion dollars is greater than the preliminary estimated value of all railroad property as made by the Interstate Commerce Commission. It is almost qeual to the combined resources of the national banks of our country. Certainly no further argument should be necessary to show the utter inability of the railroads and the municipalities to shoulder such a financial burden.

A progressive plan of crossing elimination should be carried on, and so far as the New York Central Lines are concerned this policy is being pursued, this feature being taken into consideration in the preparation of the annual budget.

A gradual process of crossing elimination has been and still is being carried on by the railroad but they have been seriously handicapped by the addition of many more new crossings. For example, in 1923 (which is the latest year for which statistics are available) the railroads of the country eliminated 972 crossings at a cost of about 100 million dollars, but during the same period 3,065 new crossings were constructed under conditions over which the railroads had no control. Even should crossing elimination be conducted on a more general scale we could not hope for a solution of the problem by this means for many generations to come. We must, therefore, accept the situation and meet the conditions as they exist.

The Motor Vehicles

We have in the United States, in round numbers, 20 million automobiles and the motor vehicle is specifically concerned since it will be involved in 90 percent of our crossing accidents this year. Not only that, but the number of automobiles will continue to increase for it is estimated that in 7 years there will be not only one car for every 6 persons as exist today, but the ratio will be increased to one car for every 4 persons; in fact, by that time we will have 33 million automobiles, a number sufficient to supply one car to each individual that is old enough to reach the steering wheel.

These statements are not made in a spirit of condemnation of the motor car, but rather they emphasize the sagacity of the American people. If we were like Siberia, with only 3 autos, and China, with 10,000 cars to supply the wants of

her 250 million inhabitants, the task before us would not be so great, but who wants to live in Siberia or China? We should be thankful we live in the best country under the sun where we have problems to solve and where we never stop until we solve them.

The automobile today is an absolute necessity in the conduct of the business of this country and progress will soon demand not only its continued use but a greater extension of its services. It is by reason of the situation that it becomes imperative that we, in our attempt to provide a remedy, not only endeavor to take care of our present day needs, but of the future as well, and this will include a regulation of the use of the motor vehicle so that it will serve the purposes for which it was intended.

Analysis of Accidents

Analysis precedes intelligent remedy.

We have followed this plan quite successfully in our efforts to reduce employee casualties and it is necessary that we follow the same method. We find 70 percent of our crossing accidents occur in daylight, 63 percent at crossings where there is no obstruction to view and a large majority at crossings with which the driver is familiar—in the country where he resides—which clearly indicates that he is so familiar with the situation he feels he is immune to danger and drives heedlessly on the tracks without using any care whatsoever; or he sees the train approaching and increases his speed in an effort to beat it over the crossing. It is, also, of interest to know that one out of every five crossing accidents results from the automobile running into the side of the train. Some drivers failing to beat the train over the crossing attempt to "butt" them off the track.

A large percentage of drivers are wholly incompetent, due to either mental or physical defects. Mental, due to inability to read or understand the English language; physical, due to impaired vision or hearing, immature age and enfeebled condition, due to old age. A large number of these accidents can be charged to intoxicated drivers. It is certainly indicative of something lacking in our laws when men of the type described as mentally and physically defective are permitted to drive automobiles. But, it is obviously grossly neglectful to permit them to be operated by drunken drivers.

A judge in one of our large cities some months ago remarked from the bench that an automobile in the hands of an intoxicated driver is far more dangerous than a loaded revolver in the hands of a maniac on a crowded street.

Contrast the comparative qualifications of the driver of an auto and the driver of a locomotive. The former, as a rule, needs no qualification other than his ability to possess a car. He is not only unfamiliar with its operation but is lacking in a knowledge of our laws governing its use on the highways. In many instances his responsibilities are such that he is weakened in his regard for the rights of others. Whereas, the locomotive engineer has earned his right to a seat in the cab of his engine by virtue of many years of training. He is not only familiar with its mechanism and operation but also with the rules governing its movement over the road. His responsibilities are a part of his makeup. He sits in his cab not only with these qualifications but with a steady hand, a clear head, a brain that is no wise affected by anything he may have drunk and with a keenness which is so alert that he is, a part of the locomotive being operated under his guidance.

While 25 percent of the drivers do not use the care requisite to safety, yet, only about 5 percent are grossly neglectful, using no care whatsoever. Thus, we find that only a small percentage of the drivers are careless, yet, if this were not true it would only be a few years until our country would be depopulated, for during last year, as a result of automobile accidents in our streets and highways, including those occurring at railroad crossings, there were 19,000 persons killed and 450,000 injured, an increase of 700 percent in 12 years. The percentage of careless drivers is small, yet, it represents a large army of 1,000,000 reckless demons flitting about the country having no regard for their own safety or the safety of their fellow men.

The reckless motorist is regarded as the greatest menace we have today in the safe operation of passenger trains for he is, indeed, a potential train wrecker. I have already called your attention to the fact that his acts in one year alone caused 27 derailments entailing serious loss of life and property.

While crossing accidents during the past 12 years have increased 167 percent and automobile accidents of all kinds have increased 700 percent it is interesting to know that during the same period passenger fatalities on the American rail-

roads have decreased 59 percent. While the railroads have in certain instances reduced the speed of some of their best passenger trains as a greater assurance of safety the speed of the automobile has increased.

In showing the comparison of safety in travel by automobile and by train your attention is called to the fact that during 1924, which is the latest year for which we have statistics, there were 19,000 persons killed by motor vehicles of which number 6,650 were passengers in the machines. There were, also, 450,000 persons injured of which number 157,600 were passengers in the machines. During the same year there were 41 passengers killed and 2,260 injured in the United States as the result of passenger train accidents. In other words, confining ourselves to casualties to persons riding in the motor vehicle and to casualties to passengers resulting from train accidents we find the motor vehicle deaths outnumber those to passengers on trains 160 to 1 and the injuries 70 to 1. For every passenger killed in train accidents there were 160 killed while riding in autos.

Before the coming of the automobile, when 16 million horses and mules were the propelling power of vehicular traffic in this country, they recognized the necessity of stopping at railroad crossings when signalled to do so by bells, gates, flagmen or other warning devices and this propelling power even took notice of the approaching train refusing to cross the track until it was safe to do so, and even with this great cavalcade upon our highways crossing accidents were relatively few, but with the coming of the automobile this responsibility was shifted to mere man and all of the elements of thoughtlessness and carelessness inherent in his makeup came forward and have made themselves felt and will continue so long as he is at the steering wheel.

The steam railroads of this country were the prime movers in the inauguration and promotion of safety in the United States. Their activities have done much to cause these principles to become so wide-spread as to include every agency that has to do with the causation and prevention of accidents. The N. Y. C. Lines have been among the foremost in the promotion of this movement and during the past 12 years, through the medium of organized safety, we have reduced employee and passenger casualties 60 percent. These remarkable achievements have been due chiefly to the spirit of cooperation between employer and employee as it relates to this field of railroad operation.

As regards public safety the public is responding to our appeals for cooperation. We are receiving the support of national, state, county and municipal officials. We are receiving aid from those organizations having to do with the manufacture and sale of automobiles. Many civic bodies are contributing nobly to this work and the churches and schools are lending most effective support. But this cooperation needs developing. If our contact with automobile drivers was as close as it is with our employees and the response towards cooperation was proportionate we could reduce crossing accidents 50 percent within a year, and eventually would bring them down to an infinitesimal number.

It seems that tragedies of an appalling nature are necessary to awaken the conscience of America. The accident frequency in this country has reached such gigantic proportions as to demand national recognition and, due to this fact, the Hon. Herbert Hoover, secretary of commerce, called a National Safety Conference, at Washington, last December. This conference devoted two days to a careful study, discussion and analysis of the accident problems. Every agency having to do with the causation and prevention of accidents participated in the program. President Coolidge in addressing the conference said—"If the death and disaster that fall upon the innocent people during the year and throughout the country as a whole were concentrated into one calamity we would shudder at such a tremendous catastrophe", and in speaking further, he said—"The yearly toll of accidents has reached an appalling total, the evil is so widespread as to be of national concern."

While America is the most reckless nation in the world yet her people more quickly than the citizens of any other country respond to appeals for aid made necessary by reason of some disaster, whether it falls on our own citizens or those on foreign soil. This is one of the traits of our people that makes for good citizenship, and since safety and good citizenship go hand in hand we may rest assured that the bulwark of safety is on solid footing, and this being true we may take courage in the belief that in the future we will see a realization of a prog-

ress in the development of safety far beyond our dreams of a few years ago.

The Remedy

What is the remedy? This is a joint responsibility between the railroads and the public. The railroads have a duty to perform. We must not lessen our efforts toward increased efficiency in the maintenance and protection of highway crossings and in the manner of train operation as it applies to accidents of this character. Our every act in the discharge of our duties in this regard must carry a sincerity of purpose of such positive character as will convince the public of our real devotion to a most worthy cause.

The remedy lies largely in a constructive campaign of education. We must find some means to curb the reckless motorist and at the same time make driving safer for the great majority of motorists who are careful.

As an aid to this plan I would suggest the public can render effective service by carrying out the following suggestions:

1. The prevention of the building of unnecessary highways across railroad tracks.

2. The elimination of crossings through the re-routing of highways wherever possible.

3. The elimination of obstructions to view on the highway within 500 ft. of the crossings.

4. Require every owner, driver and insurance carrier of every automobile involved in an accident causing personal injury to report full details thereof to designated state officials.

5. The enactment of stringent laws requiring a proper standard of qualifications, making it impossible for motor cars to be operated by those who are unable to meet the required mental and physical tests.

My belief in the justice of our cause, coupled with my deep-seated faith in the fairness of the American people, gives me hope for the future. I believe the signs of the times point to a rule of law-laying down a standard of competency to be met before licenses to drive motor vehicles will be issued. When this is done we will weed out a large army of present day drivers who, by reason of impaired vision, cannot see the train much less the crossings; who, by reason of impaired hearing, cannot hear the roar of a cannon, much less the locomotive whistle; who, by reason of mental defects, cannot understand the operation of the car, much less the rules governing its use on the highway. We will weed out the old and decrepit who have retired from every form of activity excepting the God-given right to drive the family car; and lastly but not least, we will remove from the steering wheel those whose right to operate a car is, in fact, a travesty on justice —the drunken driver whose acts are materially agumenting our casualty record at this time.

Through a greater spirit of cooperation there were 119 fewer crossing fatalities in the United States in 1924 than in 1923. It is our hope that all organizations and agencies, civic, political and otherwise, that are in any manner concerned in the conservation of life and limb and whose aid is so essential in the success of this movement will unite in a common enterprise and that as a result of our cooperation will become more extensive, so much so it will assume a force of such magnitude and power as will serve to wipe out this needless slaughter of human life.

NO CHANGES IN PAVING BRICK VARIETIES

The Standing Committee on Paving Brick Simplification, functioning with the U. S. Department of Commerce, held its annual meeting in Washington April 1. As a result of its deliberations no changes were made in the present list of four recognized varieties.

The survey of shipments in 1925 showed that a total shipment (representing 96 percent of the tonnage capacity of the industry) of 353,600,000 brick, 74.2 percent were in the four recognized varieties. Percentage for the individual sizes in 1924 and 1925 are shown in the accompanying table.

SHIPMENTS OF RECOGNIZED VARIETIES OF PAVING BRICK—IN PER CENT OF TOTAL SHIPMENTS

	Per Cent 1924	1925
Plain wire-cut—		
3x4x8½ ins.	43.1	40.7
3½x4x8½ ins.	11.0	5.1
Repressed lug—		
3½x4x8½ ins.	22.0	21.0
Wire-cut lug (Dunn)—		
3½x4x8½ ins.	6.0	7.0
Total	82.1	74.2

The decline in the percentage of ship-

ments of recognized varieties is due to the increased demand for a thinner brick. The 2½x4x8½ in. plain wire-cut brick (not a recognized variety) showed percentages of shipments in 1923 of 2.7 percent, in 1924 of 4.4 percent and in 1925 of 8.9 percent.

Increased Use of Thin Brick

Because of the evident tendency toward the use of thinner brick and because 2½ in. brick have so far stood up well in the brick road test now under way by the Bureau of Public Roads at the Arlington Experimental Station, the committee gave careful consideration to the advisability of declaring the 2½ in. brick a recognized variety. However, the committee rules provide that unless there are special reasons, a variety shall not be designated as "recognized" unless its shipments for three successive years have amounted to 5 percent of the total. Lacking a unanimous vote (which the committee's rules also require) the proposal to recognize the 2½ in. brick was lost.

Due to the increased use of thinner brick it is expected that the subject will come up again next year.

No Sizes Eliminated

The committee's rules for eliminating a recognized variety require that the variety shall fall below 2½ percent of shipments for three successive years. Since no variety came under this ruling and there were no special reasons for changes, no eliminations were made.

Technical Societies Thanked

As a recognition of the contribution of the technical societies and the technical divisions of the government to the work of the committee the following minute, signed by the representatives of the U. S. Department of Commerce, the U. S. Chamber of Commerce, the National Paving Brick Mfrs. Association and by the chairman, was entered on the records of the committee and ordered sent to the technical societies and governmental bureaus represented on the committee:

"On behalf of the National Paving Brick Mfrs. Association, the engineering profession, the Chamber of Commerce of the United States, and the U. S. Department of Commerce, we desire on this occasion to express our hearty appreciation and thanks to the members of the Standing Committee on Paving Brick Simplification (representing as they do technical, research and professional organizations and societies) who have, for the past five years, traveled varied distances at their own expense actively to participate in the deliberations of the committee. This manifestation of interest in mutual welfare, and devotion to the duties assigned them, and placing at the disposal of the committee their expert technical knowledge, counsel and experience, is in a large measure, responsible for the singular progress and success of the paving brick simplification program. As an example of constructive action by an industry, and its allied interests, this committee's work stands pre-eminent in the new order of self government in American business."

During the course of the meeting, E. F. Kelley, testing engineer of the U. S. Bureau of Public Roads, and L. W. Teller, in charge of the brick road test at Arlington, summarized the results of the Arlington tests to date. E. E. Duff, Jr., secretary of the National Paving Brick Mfrs. Association, reported that a questionnaire sent to the state highway departments had shown that the departments are well acquainted with the work of the committee, approve the plan of a limited number of recognized varieties, and are specifying the recognized varieties for their work.

There was 100 percent attendance of the members of the committee. Those present and the organizations they represented were as follows: P. St. John Wilson, Bureau of Public Roads; Col. R. K. Compton, American Society of Civil Engineers; George F. Fisk, American Society for Municipal Improvements; O. W. Renkert, American Ceramic Society; Edward E. Duff, Jr., National Paving Brick Mfrs. Association; Prof. T. R. Lawson, American Society for Testing Materials; P. E. Holden, representing E. W. McCullough, U. S. Chamber of Commerce, P. H. Bates, Bureau of Standards; R. M. Hudson, Division of Simplified Practice, U. S. Department of Commerce; Clyde L. Moyer, representing G. F. Schlesinger, American Society of State Highway Officials; E. J. Mehren, McGraw Hill Publishing Company, Chairman.

SAFETY ON THE PUBLIC HIGHWAYS

By B. H. Piepmeier, Chief Engineer, Missouri State Highway Commission, Jefferson City, Mo.

The following rules are offered as an aid to safety upon the public highways:

1. Keep car under control at all times

and be prepared to stop within one-half of the sight distance ahead.

2. Keep brakes in good repair.

3. Do not drive from a side-road or private driveway into a boulevard or arterial highway, such as a state road, without stopping and looking both ways.

4. Do not race on the highway; the unexpected is likely to happen.

5. Do not be a road hog, stay on your side at all times.

6. When turning corners or driving around sharp curves, keep to the right of side of the highway and use the horn freely.

7. Keep to the right side of the road when driving and do not pass vehicles going in the same direction on curves or on the summit of hills.

8. See that your head lights are focused upon the road ahead and not up in the air. Do not use excessively bright lights. Keep both head lights burning at night. Insist upon horse-drawn vehicles carrying lights.

9. Always signal driver ahead when you want to pass from the rear, and then be sure that you pass on the left side.

10. Frequently examine the tail light, and see that it is operating.

11. Keep your eyes on the pavement or traveled way ahead of you and avoid driving off the surface.

12. Always be on the lookout for loose gravel, mud, etc., when making an abrupt turn.

13. Always walk on the left side of the pavement or traveled way. Instruct others to do this.

14. Avoid a sudden stop, and do not park on the pavement or traveled way.

15. When turning corners, stopping, etc., give proper signals with hand in sufficient time so that approaching traffic may have warning in due time to avoid accidents.

16. Make repairs on side-roads, or entirely clear of the pavement or the traveled way.

17. Carry a pair of good wheel chains for emergency use.

18. Drive carefully when the pavement or roadway is wet or slippery. Spots covered with mud, snow or ice may cause you trouble.

19. The increased mileage of improved roads increases the amount of travel and the speed of traffic. Therefore, be careful at all times. It is better to be safe than sorry.

20. Observe all warning signs. The orange or yellow diamond signs indicate possible danger upon the highway and warn the travelers to reduce their speed. The orange or yellow hexagonal signs indicate stop, and should be observed for safety. The orange or yellow square signs are primarily for information, and the traveler should always observe these signs; they do not, however, mean that the traveler must reduce speed, but that he should be on the lookout for a possible hazard independent of the road, such as a school, side-road, etc.

21. The road engineer and builder are striving to help make all roads safer by relocating many sections, building longer curves and superelevating them, by building wider bridges, heavy guard fences, subways and viaducts under and over railroad crossings, marking center strips on pavements, erecting warning signs, etc. The engineer and the builder must, however, have the cooperation of the traveler to insure safety to life and prevent destruction of property. The careless driver is a menace to traffic and the cause for stringent rules that are frequently unnecessary and impose hardships upon others. Every driver should be careful and courteous upon the highway for the good of all concerned.

The following is an excerpt from the Missouri law regarding safety and speed upon public highways:

"Sec. 19. Operation of Motor Vehicles. —Every person operating a motor vehicle on the highways of this state shall drive the same in a careful and prudent manner, and shall exercise the highest degree of care and at a rate of speed so as not to endanger the property of another or the life or limb of any other person: Provided, that a rate of speed in excess of 25 miles an hour for a distance of one-half mile shall be considered as evidence, presumptive but not conclusive, of driving at a rate of speed which is not careful and prudent, but the burden of proof shall continue to be on the prosecution to show by competent evidence that at the time and place charged the operator was driving at a rate of speed which was not careful and prudent, considering the time of day, the amount of vehicular and pedestrian traffic, condition of the highway and the location with reference to intersecting highways, curves, residences or schools."

SELECTION, CARE AND OPERATION OF FIRE FIGHTING EQUIPMENT

By Harry J. Corcoran, Chief Engineer, Iowa Insurance Service Bureau, Des Moines, Iowa

(Paper read at First Short Course for Fire Fighters at Iowa State College, Ames, October, 1925.)

The selection, care, and operation of fire-fighting equipment is a subject about which a book might be written. Naturally, a general discussion is all that can be handled here. Consideration of minor tools and equipment will be left out for the most part in favor of the larger pieces of apparatus.

Difficulties of Selection

In the smaller communities the selection of new or additional equipment is usually decided by the town council. Councilmen and fire chiefs in such towns are often perplexed by the variety of equipment available, and they do not always know where to get unbiased information. Almost any automobile carrying fire-fighting equipment looks fine when contrasted with hand drawn carts, while the cost of even the cheapest truck seems enormous. It is hoped that the information given here will prove helpful to municipal officials in their selection of new or additional apparatus.

Only one thing should govern the choice, namely, the requirements for reliable protection. While, unfortunately, financial limitations are the controlling factor in the case of smaller towns, in a city able to maintain a paid fire department there should certainly be enough money available to buy equipment on the basis of its suitability.

Advantages of Motorized Apparatus

The introduction of motorized apparatus is spreading rapidly throughout towns of all sizes. This is mainly due, of course, to certain important advantages possessed by automobile apparatus. Motorized apparatus relieves the firemen of much labor in getting fire-fighting equipment to the fire, so that they arrive fresh instead of exhausted; it permits the carrying of more tools and equipment on one rig than is possible when hand-drawn carts are used; and such apparatus possesses the important advantage of greater speed in going to the fire.

With motorized apparatus, however, there should always be some kind of reserve equipment that can be relied upon in an emergency. Any automobile is liable to breakdown or accident; and when this happens to a fire truck on the way to a fire, it is a serious matter. In towns where one car is normally adequate for protection, a hand-drawn reserve that can be towed behind pleasure cars serves quite well in such an emergency.

Chemical Engines

A village with two half-blocks of frame and brick buildings of one and two-story height can experience a rather severe fire. Fire protection adequate to stop the spread of such a fire would require several heavy streams of water. The total value of property in such a business district may not exceed $100,000, while the cost of the waterworks that could be counted on to stop a serious fire would easily reach $20,000, and might be entirely out of the question. In such cases, the common solution is to install a chemical engine to provide some measure of fire protection. Equipment of this type will not stop a large fire, but if it is used in the early stages of a fire it will often prevent the fire from spreading. Such a chemical engine may be hand-drawn or motor driven and may carry from one to four tanks (usually two) with a nominal capacity of 35 to 40 gals. each.

Soda-and-acid extinguishers. For general use the soda-and-acid type is most suitable. With hand-drawn equipment it is better if the acid is in sealed bottles which must be broken to operate the engine, although loose stopple types are in successful use. When pulled over streets behind automobiles the loose-stopple style may slop acid and generate pressure too soon. If the tanks are mounted on an automobile, however, there is little trouble from slopping, and in that case the simplicity of the loose-stopple type makes it preferable. Tanks are made both of copper and of steel, and they must be lined with lead or zinc. The lining of steel tanks can be successful with proper workmanship. If possible, there should be two lines of small hose provided, so that the fire can be attacked from two places.

The manner in which this type of extinguisher puts out a fire is really twofold. When the acid and soda solutions mix, carbon dioxide gas forms, creating a pressure of 200 lbs. or more. A stream of water is forced out by the pressure thus developed in the tank, and this water quenches the fire that it strikes. The

carbon dioxide gas is carried out with the water and it tends to smother the fire. This gas is heavier than air and settles; hence it is most effective when the fire is low and confined. When a fire is in the open there is little effect due to the gas; plain water would serve just as well, but a pump would be necessary to furnish the pressure.

Foam extinguishers. A type of extinguisher that generates a thick foam is growing in favor, and it is particularly effective in fighting grease and oil fires. and it floats on oil, thus acting as a blanket to smother the flames. When used for general fires, the foam must be sprayed on all parts of the burning surfaces. The large use of oils in all cities and towns warrants the installation of such extinguishers, at least of the portable type.

Maintenance. All kinds of chemical engines need regular attention if they are to give satisfactory service. The soda-and acid type should be discharged, thoroughly cleaned, and recharged once each year; and the hose, nozzles, and other working parts should be carefully inspected. There is often trouble due to corrosion, and sometimes there are leaks; these are hard to stop if once started. The tank should be carefully cleaned and the packing renewed if the trouble is bad; coating affected parts with a good grade of vaseline will sometimes help.

Chemical extinguishers of both of these types must be protected from freezing, and of course they work best when fairly warm. Occasionally complaint is heard that the acid and soda do not mix readily, and that the acid destroys cloth. When the device is properly charged, this cannot happen; if the soda solution is old and the mixture is cold it is possible that some weak acid might be discharged, but even with the worst conditions this is unlikely.

When the extinguisher is refilled, the tank should first be carefully cleaned. The new soda must be thoroughly dissolved in the water; mixing in a bucket or tub is the best way to do this. Care should be taken to use the exact amounts of soda and of acid recommended by the manufacturer. All reliable manufacturers of extinguishers furnish complete instructions for the proper care of their equipment.

Use of chemicals. To be effective, all chemical extinguishers must be put into use before the fire has really got a good start. This means that the firemen must thoroughly understand them, so that they will not lose time at an actual fire finding out how they work. Not long ago a serious fire occurred in a town near Waterloo because the tank had not been properly assembled after a former fire. Occasionally the tank is left uncharged in cold weather to avoid the cost of the fuel necessary to keep it warm; in such a case the money spent for the machine would better have been given to charity.

Carrying extinguisher tanks on an automobile speeds up their use, and such a machine is of course much better than a hand-drawn machine. It can also carry the ladders, axes, and other tools commonly needed at a fire. Longer hose lines will be needed than with the hand-drawn equipment, because the truck must stop at the curb. There should be at least 150 ft. of hose in each line. The machine should be able to carry five men and make good speed under full load.

Fire Fighting With Water

Some towns that cannot afford to install water works build cisterns in various parts of town and rely upon a pump carried on an automobile to force the water through hose to the fire. A few places have rivers flowing through their areas that can be used as water-supplies for fire fighting. With either plan permanent landing places for the pumpers must be provided, and definite plans made for fighting a fire in any building. The pump should of course be adapted in size to the supply of water available, and it should be of a reliable make. Home-made or assembled equipment for this purpose can only be classed as makeshift; a machine made by a reputable manufacturer should be purchased if at all possible. More will be said about this type of equipment later.

The first thing to determine, where it is planned to use water from a lake or river for fire fighting, is the actual ability of the pump to take out the necessary water. In order to get good results it must be possible to set up the pump on a solid structure or on level and solid ground, so that it is not more than 16 ft. above the water surface and within 10 or 15 ft. of the water edge.

When a public water-supply with street hydrants is available, water will of course provide the means for stopping a serious fire. The selection of equipment

is largely a matter of determining how to get the water from the hydrant to the fire. Excluding hand-drawn hose reels, all modern fire-fighting apparatus used in connection with a water works is motorized. Fortunately it is divided into a few general types, with special apparatus only for large cities.

Hose Carrying Apparatus

Taking up first the hose-carrying apparatus, the type to choose will depend upon the pressure and quantity of water available from the water system. If there is adequate pressure at the hydrant while large quantities of water are being used, a pumping engine is hardly necessary.

The simplest type of apparatus is the hose car; one or more chemical tanks are usually carried to form what is termed the combination hose-and-chemical car. The pumping engine practically always carries hose; if large chemical tanks are carried it is called a triple-combination engine. Ladder trucks are either aerial or service trucks; they often carry chemicals. There is a combination ladder-and-hose truck made, but few are used.

When buildings are three stories in height or higher, few water systems can furnish large quantities of water at the necessary pressure direct from the hydrants. The amount of water available over the time a large fire might last also has a bearing on the question; an adequate supply of water is needed when a pumping engine is in service. The distribution of hydrants must also be studied.

Hose-Car Equipment. Ordinarily a hose car should carry 1,000 ft. of 2½-in. hose, a 26-ft. to 30-ft. extension ladder, a hook roof ladder, two or more nozzles with an assortment of ¾-in. to 1⅛-in. tips, and one or more large chemical tanks. Chemical extinguishers are used in putting out a majority of fires, even where a good water system exists, and longer lines of chemical hose will be necessary than with hand-drawn engines—they should be at least 150 ft. in length.

Large hose is usually laid on the way to the fire, which permits using the chemical and a water stream together if desired. Provision should be made to supply water to the chemical line from a large hose by means of a threaded cap attached to the piping from the chemical tank. A special reducer wye can be screwed to the end of the large hose, and one to three small hose lines used for many dwelling fires and for cleaning up at fires in business buildings. This necessitates carrying small hose, which is usually 1½ ins. in diameter and in 50-ft. sections.

Ladders. More thought should be given to the selection of ladders than is usual. When a town installs an automobile hose-and-chemical car, the hand-drawn ladder truck is often allowed to become unfit for use. For this reason there should be on the car at least one good extension ladder that will reach any roof, as well as one shorter ladder.

Design. The particular make to select is more or less a matter of opinion. In smaller communities the number of runs per year and the size of the town will often permit a commercial truck chassis to be used to good advantage. When this is done a car with a good pick-up and strong transmission is necessary. There should be sufficient engine power to carry five men, in addition to its equipment, at a speed of at least 20 miles an hour. Local facilities for maintenance are also worth considering if a commercial-truck chassis is bought.

Combination Cars

Larger towns handling 25 or more calls a year should get the best kind of combination car, one that is especially designed for fire service only. Such a car will prove economical and more reliable in the long run.

Up to the past three or four years it was the universal opinion that a triple-combination car was about the last word in fire-fighting equipment for the small town; a town owning one of them (providing it was small enough to need no more than one company) was considered well fixed. Experience is showing that this is not always true.

Combining the chemical outfit with the pumping engine prohibits the most effective use of either. This is not particularly serious in itself, as only a slight delay is caused by picking up the chemical hose before going from the fire to the hydrant to connect the pump; but the congestion of traffic near a fire in even one of the smallest towns often causes delay, and sometimes the car is totally blocked. In order to overcome this trouble several towns have purchased or built straight chemical cars, each provided with two tanks, while others have installed combination hose-and-chemical cars which also serve as reserve hose carriers. Of course every

community should pass and enforce a traffic ordinance containing provisions designed to keep the streets clear near fires.

Arrangements are frequently made with farmers within three to five miles from a town to furnish them protection in return for their help in buying a truck. This arrangement means that two cars are absolutely necessary, and in such a case the combination of hose and chemicals on one car, with pump and hose on another is a good one. The pumper can respond if the roads are good and water in quantity is available; while with bad roads or no water the chemical or combination car can be sent.

At least two reputable manufacturers have replaced the usual chemical tank with one or two large water tanks, the pressure being created by the regular pump. This plan has many advantages. The first cost is lower, a larger stream of greater reach is available, the capacity of the tanks is greater, and it is easier to keep a continuous stream working.

Pumping Equipment

The development of the automobile pumping engine has just about revolutionized fire fighting in the past ten years. They are made in a number of standard sizes and combinations up to 1,000 gals. a minute capacity, but only the types more commonly found will be considered here. It is safe to say that such a machine is really needed in 95 percent of such communities in Iowa as have water systems. A safe rule of general application calls for some pumping equipment for the fire department (1) when buildings do not exceed two stories in height and a discharge of 500 gals. a minute reduces the hydrant pressure to less than 50 lbs., or (2) when buildings do not exceed three stories and the same discharge produces a hydrant pressure of less than 60 lbs.

Selection of pumpers. A machine of this type costs a lot of money, however, and the council or the committee entrusted with its selection must be careful to get the best the money will buy. Without question the community should purchase the very best pumping engine that can be financed. Any community that can maintain a public water-supply system suitable for fire protection should be able to invest $5,000 or more for a pumping engine. The annual cost of such a machine, distributed over its normal life, is moderate.

The first thing to determine is the size of pump that can be used. Few towns under 20,000 population have water-supplies that are really adequate, and the water distribution system must be studied to learn the maximum and minimum quantities obtainable from the hydrants and, also, how many hydrants can furnish a large amount. More than one case is known where these studies were not made. When the machines were delivered to these communities it was found impossible to run them at full capacity or even three-fourths capacity except at only one or two spots in each community. Elsewhere the water mains were too small to deliver enough water.

The business district will be the scene of the biggest fires, and in general the amount of water available from hydrants in this area can be safely used as a guide to the size of pump needed. It is not necessary to run a pumper at full capacity to get good streams, but there is nothing gained by buying an oversized one. The most progressive manufacturers are recognizing this and are building machines to work satisfactorily at a small fraction of the maximum capacity. Efficiency as to fuel used is of course low, but this feature should be the last item to influence the choice of make. Plans to build up the water system in the future may justify the purchase of a larger pump than can be put to use immediately.

Specifications and tests. The commonly accepted standerds for these machines consist of the Underwriters' Specifications and the 12-hour test prescribed by the International Association of Fire Engineers. No machine that has not passed a standard 12-hour test at the rated capacity for which it is sold can be considered reliable; that is, a machine built to the specifications mentioned must pass this test.

The individual machine should be bought subject to a satisfactory 3-hour Underwriters' Acceptance test. The Iowa Insurance Service Bureau will send an engineer to any town in the state to test a pump when it is delivered, without charge. A local test is really more satisfactory to the town than one at the factory, though a factory test is acceptable if made by a competent and uninterested party.

This test requires that the machine shall pump water at its rated capacity against 120 lbs. net pressure for 2 hours,

½ of its rated capacity against 200 lbs. net pressure for 30 minutes, and 1-3 of its rated capacity against 250 lbs. net pressure for 30 minutes. When these requirements are studied it will be realized that they demand very good material and workmanship.

A pump should have gauges to show the suction and discharge pressures, a positive-acting relief valve, and an ample return or churn pipe from the discharge to the suction, and a lock for the pump gear-shift levers. While not absolutely essential, a comparatively low-speed motor is more reliable than one of high speed; about 1500 r. p. m. is the dividing line between low and high speed.

It is a common experience that a pumper is seldom used to capacity, and unless regular tests are made it may fail when most needed. A half-hour test on a machine every few months at full capacity will often uncover a needed repair; defects commonly found include cracked cylinders, clogged cooling systems, leaky engine packings, dry pump bearings, defective pumps, worn clutches and weak gears.

Operation of pumpers. All the members of a company should understand the principles of pumping. The regular operator should know his machine thoroughly, and should be able to keep it in first-class condition. This is very necessary in the small town. At least one other man should be able to operate it under any condition. It has been a common experience, with volunteer departments, to find the operator away from town and no one left who understands the pump. It is also very common to find that no member of the department, from the chief down, knows the rated capacity of the pump within 250 gals. It should be easy to imagine the impression this creates. Such a condition of affairs is a fair indication of the kind of fire-fighting the community may expect.

Many departments are over-confident concerning the performance of a pumper —the machine is considered more or less automatic; all that is required to get any desired result is to connect it to the hydrant and throw in the pump clutch. Wonderful things can be done with a pumper, but a reasonably good knowledge of pressures, the friction in hose and in water systems, as well as the effect of nozzle sizes on pressure is essential to satisfactory results. On the other hand, some departments are afraid of their pumper. It is so powerful that they do not trust it; it seems so complicated that something seems sure to go wrong if they work it up to capacity. Continued practice under varying conditions is doubtless the best remedy for both conditions, because they are largely mental.

When a pumper is owned, equipment for handling large streams is desirable, especially such equipment as deluge sets and cellar pipes.

Ladder Equipment

Ladder equipment is necessary for two reasons: (1) to save life and (2) to help fight fires. A fire department should never lose sight of the fact that they probably will be called upon sometime to rescue people from a burning building. For this purpose ladders are indispensable, because if the normal means for getting out of a building were not cut off there would be no need for rescue. People will often climb to the roof of a building to escape the heat and smoke; this should be borne in mind and a ladder provided to reach to the highest roof in the town.

Use of ladders. Ladders are needed in fire fighting to carry hose and other equipment to upper stories or to the roof, to get into attics, and to provide footing for nozzlemen directing streams into windows. In addition to placing ladders, a ladder company should be equipped to open up a building for hosemen to enter, to ventilate a building, to assist generally in getting at a fire, and to protect the contents of building from avoidable damage. Towns and cities in Iowa are quite generally in need of much improvement in their ladder equipment.

Ladder trucks. In any town having as many as a half-dozen buildings of three or more stories, a ladder company with a well-equipped truck is necessary for reliable protection. When few buildings exceed three stories, a city service truck is satisfactory; but with as many as five buildings higher than this, an aerial truck is warranted. Small communities having but one or two buildings over two stories in height can usually carry sufficient ladders on the hose cars, or they may install a light ladder truck, depending on local conditions. When no building height exceeds two stories, a 30 ft. extension ladder and one or two scaling ladders are satisfactory equipment. The usual practice is to carry a 24-ft. extension ladder on the hose car,

but this is only safe when a fully-equipped ladder truck is available. For towns with less than five three-story buildings a light truck with 40-ft., 30-ft., and 24-ft. extension ladders, as well as two wall ladders and two scaling ladders, can be kept in the station and taken only to fires in the business district. If a motorized truck cannot be purchased, the ladder truck can be fitted with a tongue or rope and hauled behind an automobile when needed, but this practice is not recommended.

In the city department in Ames, a service truck with a large chemical tank and several hundred feet of hose is used as a combined hose and ladder truck; the need for ladders in this city is apparent because of congested housing during the school year and the general use of attics for sleeping rooms, brought about by this condition. Such a machine would be well suited to many towns.

Ladder-truck equipment. A motorized service truck should of course be provided where a ladder company is needed. With ladders up to the 50-ft. size, the machine can be driven by its rear wheels and steered from the front seat; longer ladders usually mean a tiller or rear-steering device. Standard makes of service trucks carry one 50-ft., one 40-ft., and one shorter extension ladder, as well as several straight and scaling ladders. Extension ladders and the longer wall ladders are preferably of the trussed type, that is, the sides or rails are not solid but are built of light strips so placed as to give strength without unnecessary weight. Fire department ladders may be called upon to carry heavy weights, and for this reason the ordinary types of ladders used by carpenters and painters are not suitable.

Wrecking tools make up most of the other equipment ordinarily carried on ladder trucks, such as axes, picks, door openers, pike poles and plaster hooks, rope, wire cutters, bars, and roof cutters. Waterproof covers, brooms, forks, shovels, and mops can be carried and used to great advantage in protecting the contents of buildings from undue water and other incidental damage.

Aerial ladders. The modern aerial ladder is mechanically operated or raised, but a trained crew is needed for quick work. Usual reaches are 65, 75, and 85 ft., when fully extended, the ladder being in two or more parts called the 'bed ladder' and the 'fly'. Two drivers are needed on American trucks, because the length of the bed ladder requires a tillerman. The front wheels are the drive wheels, some models having a four-wheel tractor in front, partly to simplify the steering equipment and partly to distribute the weight.

A very compact model has been introduced from Europe, with a ladder in several sections. This permits a much shorter wheel base, which makes this type of truck appear to be an advance so far as handling in traffic is concerned. Only the one ladder is carried on the standard model of this type of truck.

The aerial ladder usually is and always should be equipped with a ladder pipe and nozzle. This is a large-sized hose fastened to the ladder with the nozzle at the upper end of the bed ladder. The direction and elevation of the nozzle can be controlled from the ground by ropes. Such equipment makes it possible to direct a nearly horizontal stream into upper stories, but good pressure is needed for a large stream.

A life net and safety belts are carried on an aerial truck, in addition to the usual tools. Pompier scaling ladders may be carried, and they are excellent for training; their use at fires is spectacular, but of doubtful value except in the greatest emergency.

Care of ladders. Fire department ladders need regular attention to check up on any development of weakness. New ladders are coated with a good grade of varnish, which should be preserved or renewed. This not only improves the appearance of the ladders, but it keeps the wood fibers from loosening and fraying. It also retards dry rot and lengthens the life of the ladders. Some departments prefer paint to varnish, but paint covers many defects that a clear varnish does not.

Ladders should of course be handled carefully in order to avoid cracking the rails or the rungs. The wood used in such ladders is carefully selected and treated to give the maximum strength and life; but such ladders are not built to use as battering rams to break doors, and they should be so used only in an emergency.

Extension ladders. Extension ladders have moving parts that need constant inspection. The sheaves should be free running, but not loose; the rope should lay straight and be sound throughout; and the locks should work freely and

positively, both in raising and lowering the fly. Extension ladders 35 ft. long or longer require stay poles to make raising easier and to hold the ladder steady when the fly is in use. These poles must be sound and not warped, with strong fastenings if permanently attached to the rail.

A ladder truck is built to hold the ladders securely, with quick-releasing clamps and enough supports to keep them from sagging and becoming warped. When extension ladders are carried on hose cars, similar precautions should be taken. If a ladder overhangs at the end more than four rung spaces, or if the center supports are more than eight spaces apart, the ladder is apt to sag and in time will become sprung or warped; also, a longer overhang may cause vibration or whipping during a run. The ladder must be fastened so that it will not slide back and forth with each change in the speed of the car. A ladder should never be strapped to its supports or fastened in any like manner. Such a plan discourages removal for practice purposes and will surely cause delay and confusion when the ladder is needed.

Truss ladders. Truss ladders have already been mentioned. Most ladders of this type have a top side and a bottom side, in much the same way that a bridge truss has a top and bottom. In fact, a trussed ladder is built on the same principle as a trussed bridge. If it is set up wrong, a ladder may break with a heavy load, this being particularly true with extension ladders. It might be well to mark ladders if seldom used, but that would look like poor firemanship.

Raising ladders. There is one proper way and several poor ways to raise a ladder, just as in the case of most operations. The time to learn the right way is in practice or drill. The handling of ladders seems to be one thing commonly neglected by most volunteer departments and many paid departments in this state, even when they have the ladders to use. Possibly this is because of the supposed hard work involved in such practice, or because of the inherent belief that anyone can raise a ladder. If properly done there is little difficulty in erecting a long extension ladder, but teamwork on the part of the crew is needed. It takes from three to six men to handle an extension ladder, depending on the length. A rough rule to follow is to allow one man for each 8 ft. of total length.

While it is true that any group of men with ordinary intelligence can get a ladder from the ground into the air, to place it just where it is needed and so that it will bear the greatest possible load requires training. A ladder must be set so that the bottom will not slip, but it must not be set up too straight or the men cannot work upon it. It is often necessary to carry hose up ladders, to fasten a hose line to a ladder, and occasionally to carry a person down the ladder. A safe rule for determining the distance the bottom should be away from the building is this: Divide the distance in feet from ground to the top of the ladder (that is the point where the top will be) by five, and then add two; this rule gives the distance in feet.

Care of Equipment

Every piece of fire equipment, and particularly motorized apparatus, should be under the supervision of a competent person; a routine system of inspection and operation will probably prove best. An engine should be well worked before putting it into service, for it must be remembered that a fire truck may be called upon for maximum power and speed within a week after its installation and regularly thereafter. After each run the machine should be carefully inspected for loose parts, such as nuts, spring clips, engine parts, hub caps, and such other parts or fittings as are apt to work loose.

Driving such a machine is similar to driving a well-loaded delivery truck, so drivers must learn the feel of it; ability to drive a pleasure car does not fit a man to drive a fire truck. A speed of 25 miles an hour is ample in small towns, and reduces the possibility of accident.

The engine and the driving parts of the truck can best be taken care of by a local garage. The care of fire-fighting equipment is up to the fire chief. Care of chemicals is the same for motorized apparatus as it is for hand-drawn; if the chemical tank is over the hose bed (where it should not be) great caution should be taken not to spill acid on the hose. The gasoline tank is better filled at a regular filling station than from a barrel with a bucket or can.

Concluding Suggestions

This covers the general field of apparatus normally used, and the times when special apparatus are needed are so rare that such equipment will not be discussed at this time.

There are many manufacturers who sell fire-fighting equipment and the num-

ber seems to be increasing. Certainly increased efforts to sell apparatus are under way in this state. The greatest competition is in pumping engines; more or less conflicting claims are made as to superiority of different sizes of pumps, of different types of pumps, of different drives, as to the suitability of 4 or 6-cylinder engines, and as to various other items. It can only be said that any type is satisfactory if the design is sound and the power is suited to the work demanded. Naturally no one make can be recommended over others.

When new apparatus is about to be purchased, it will pay to get the opinions of several other fire departments and experienced fire chiefs, as well as to get the specifications of the National Board of Fire Underwriters, to be used as a standard of comparison. It is human nature for a salesman to be enthusiastic about his own product, and for this reason too much weight should not be given to the statements of any one salesman. Above all, attempts to get too much for the money available should be avoided.

Probably it is not necessary to urge fire chiefs to think of additional apparatus before it is badly needed, but certainly councilmen are prone to delay until the last minute. It is not good policy to wait until fall to start selecting a machine for the following winter. It takes forty-five to ninety days to build a machine. Probably half the engines tested in Iowa in recent years have been delivered after the middle of January.

RECOMMENDED ASPHALT PAVING MIXTURE PRACTICE

By Prevost Hubbard, Chemical Engineer, The Asphalt Association, 441 Lexington Ave., New York, N. Y.

(A paper read at the Second Annual Conference of the North Atlantic States Highway Officials, at Syracuse, N. Y.)

The subject of this paper logically may be considered as a continuation of a former paper on the trend in bituminous pavement design with specific reference to asphalt paving mixtures. In connection with the composition and use of such mixtures the writer feels that the beginning of important advances has been made which ultimately will clarify our knowledge of paving compositions and will broaden and simplify certain of our customary specification requirements.

During the past few years a new school on asphalt paving has been developing due to the fact that careful thinking engineers who have been studying the behavior of asphalt pavements under modern traffic have become somewhat skeptical of the logic, if any, back of certain of the specification requirements which have been handed down by an older generation largely responsible for the early development of the industry. The more or less arbitrary specification requirements dictated by the experience of a few pioneers in asphalt paving have as a rule been accepted without question because they seemed to work out fairly well. Careful observers, however, have repeatedly noted that where certain of these requirements have been violated in practice no bad results have followed and in some cases superior pavements have been developed. In other words, it has reemed that while our customary requirements are reasonably safe some of them are unnecessarily and perhaps unreasonably restrictive. This applies particularly to the composition of paving mixtures. On the other hand there is growing evidence that certain construction requirements in particular should be more restrictive and much more rigidly enforced in order to secure the best results.

Recently in Chicago a new association was organized for the specific purpose of investigating and studying all phases of asphalt paving. This organization is known as the "Association of Asphalt Paving Technologists" and is expected to serve as a clearing house for all new and useful information developed upon the subject of asphalt paving. A number of working committees have been appointed, among the most important of which are the one on research on paving compositions and that on control of street operations. The organization of this association is the direct result of the widespread and rapidly increasing interest of the country as a whole in asphalt pavements, an interest of much greater magnitude than the writer believes is appreciated by many engineers whose attention has been centered principally upon the construction of the rigid types of pavement.

In this connection you may be interested in knowing that last year there was constructed in the United States a greater yardage of asphalt pavements than of all other pavements combined, of a type higher than waterbound macadam. The most recent Federal statistics show that in 1924 over one and one-half million tons

of asphalt were used in pavement construction. Since 1910 the annual yardage of asphalt pavements constructed in this country has steadily increased from eighteen million to more than one hundred and forty million square yards, giving a grand total, for the past sixteen years, in excess of one billion square yards. Reduced to a single continuous road twenty feet in width this represents about eight-five thousand miles of road, more than sufficient to circle the world three times.

If production statistics of the leading highway material industries are compared for recent years it will be found that asphalt shows a greater proportional gain than any of the others, with the possible exception of gravel for which the latest available figures are for 1923. Taking the production for 1919, the first post war year, as 100 and plotting the production of these industries through 1923 it will be found that petroleum asphalt showed an index of about 185 as against 162 for its nearest competitor and exceeded only by the index for gravel production. In 1924 the asphalt index was about 239 and in 1925, 260. These figures are given merely for the purpose of illustrating how important is the asphalt pavement as a factor in our country's paving program and to what extent it warrants the careful study and attention of highway engineers.

Before describing some of the most recent work of investigators who are endeavoring to increase our knowledge of asphalt paving mixtures it is desired to direct attention to a few extremely important construction details which were mentioned in the writer's paper last year but which frequently are slighted because of failure to appreciate how vital they are in producing a durable and otherwise satisfactory pavement. Observance of these details are very essential in the construction of hot-mix asphalt pavements from the standpoint of stability, resistance to scaling, disintegration due to water action and uniformity of contour.

Undoubtedly the most important single construction detail is initial compression and the use of a heavy roller for first compression of the hot paving mixture cannot be too strongly urged, particularly if the pavement is to be subjected to heavy traffic. In the past it has been customary to roll the fine aggregate asphalt paving mixture, at least, with a relatively light tandem roller, prior to using a heavy roller but this is now known to be less satisfactory than the practice of using the heavy roller first. A light roller will compact the upper portion of the paving mixture satisfactorily but it fails to compress the lower strata, thereby forming a crust which serves to distribute the load of the heavier roller later used, to such an extent that thorough compaction throughout the depth of mixture is not secured. Such a pavement if opened to heavy traffic immediately after construction, is much more likely to develop waves and ruts than is a pavement initially compressed with the heavy roller. Even when the heavy roller is used the best results can only be obtained by continuous rolling at a rate not to exceed 200 sq. yds. per hour per roller. This matter is considered to be of such vital importance that during the past year the Asphalt Association has revised its construction specifications, which had previously permitted the use of a lighter roller for initial compression, to read as follows:

"While still hot the surface course shall first be thoroughly and uniformly compressed by a power driven roller weighing not less than 10 tons. Subsequent compression may be obtained by a power driven tandem roller weighing not less than 5 tons. Rolling shall proceed at an average rate not to exceed 200 sq. yds. per hour per roller continuous rolling for each roller weighing not less than 10 tons and shall continue until no further compression is possible."

Use of the tandem roller is advisable for diagonal and cross rolling where initial compression has been obtained with a three wheel roller. Considerable care is required, however, to use the three wheel roller to best advantage on sheet asphalt or fine aggregate mixtures. The roller should be backed on to the hot mix and operated very slowly, care being taken not to reverse too suddenly. The large narrow wheels cut into the mixture to some extent but compress it from the bottom up so that reasonably uniform density is secured throughout the entire depth of mixture. The extreme importance of maximum initial compression has been demonstrated by laboratory studies of paving mixtures which will be discussed briefly later.

Uniformity of contour in the newly constructed pavement is the second important construction detail to observe. This,

of course, is dependent to a large extent upon the care with which the paving mixture is rolled but even with the best of rolling it cannot be secured unless the material has been properly spread and raked by experienced rakers. The mixture should be combed out throughout its entire depth. The use of a wide-spaced, deep-pronged rake somewhat resembling a potato fork has been used successfully by some progressive contractors and it is to be recommended. Where it is necessary that workmen stand at times upon the newly raked material, sandals to the bottom of which are fastened pegs of suitable depth should be worn. In endeavoring to improve the contour of their pavements a number of contractors have found that the use of lutes about 5 ft. in width are of material assistance. An improved method of placing the mixture has also been adopted with good results. This method consists in spreading the mixture so as to produce a working edge in the form of an inverted V with the apex at the center of the road. The rakers can then stand within the V and rake the mixture diagonally toward the center thus entirely eliminating the tendency to produce raking corrugations at right angles to the center line, which are sometimes noted when the working edge is carried directly across the pavement. When the V shaped method of spreading is adopted it will be found advantageous to roll the pavement along lines paralleling the sides of the V after the roller has rolled a single longitudinal strip along each side of the road. Such rolling also tends to prevent the formation of construction corrugations.

Mechanical spreaders have been used successfully in the construction of certain types of hot mix asphalt pavements and it is probable that they will be used more extensively in all types in the future. A special form of tamping roller has also been devised for the purpose of increasing initial compression but the use of this device is still in an experimental stage.

In his paper last year the writer mentioned the trend toward the use of harder asphalt, a lower percentage of asphalt and a higher percentage of filler in paving mixtures and it may be stated that this trend is becoming more and more pronounced. Considerable information regarding the composition of asphalt paving mixtures has been secured through laboratory investigations which, so far, however, have been confined principally to fine mineral aggregate mixtures.

The Asphalt Association has devised a test for determining and controlling the stability of asphalt paving mixtures which is adaptable for use not only on samples of mixtures prepared in the laboratory but upon core samples of pavement taken immediately after construction or at any time during the life of the pavement. This apparatus has been used to study various factors influencing the stability of paving mixtures and has already developed a considerable amount of useful information which, it is believed, will be of considerable value in connection with future work. The method of test was described in detail in a paper presented by the writer before the American Society for Testing Materials last June and only a brief description will here be given.

In the preparation of laboratory test samples a mixture of hot mineral aggregate and asphalt cement first is made under conditions approaching as closely as possible those obtaining at paving plants. From each mixture while hot three cylindrical briquettes are compressed in 2-inch cylindrical molds under a load of 3,000 lbs. per sq. in. The briquettes are then ejected from the molds and allowed to cool over night. They are then placed in a water bath and brought to a temperature of 140° F., the temperature selected for the test of stability, because it approximates the maximum temperature to which the mixture is likely to be subjected under traffic and the temperature at which it is most likely to displace under traffic. The test on each briquette is made in the water bath by placing it in a testing mold of slightly larger diameter with a circular bottom orifice 1¾ ins. in diameter. A plunger is placed on top of the briquette and a rapidly increasing load is applied until the maximum load required to force the mixture through the orifice is reached. The average maximum load developed by the three briquettes is then recorded as the stability value of the mixture. When it is desired to subject actual pavement samples to this test a short section of 2-in. diameter pipe, sharpened at one end to a cutting edge is jacked into the pavement and when removed brings with it a core sample of the pavement which can be placed in the testing mold and tested after the top and bottom faces have been trued up.

This apparatus has been used in test-

ing a large number of experimental mixtures. It soon demonstrated the fact that the stability of any mixture containing a low percentage of filler is materially increased by the addition of increasing amounts of mineral filler up to a certain point and that different fillers possess different stabilizing values when used in equivalent percentages of the total mix. The tremendous importance of high initial compression has been clearly demonstrated by this test which, for certain mixtures, has shown that stability is almost directly proportional to the load to which the mixture was subjected during compaction. The factor is of such great importance that it overshadows many of the other factors which have a direct bearing on stability. It may be said, therefore, that failure to obtain high initial compression may result in the instability of a mixture which is inherently extremely stable so far as its composition is concerned. The test has demonstrated that the percentage of asphalt used in the mixture is important also from the standpoint of stability and that, in general, maximum stability is obtained in the fine aggregate mixtures by the use of a smaller percentage of asphalt than has been thought advisable heretofore. This factor, however, is directly dependent upon the percentage of mineral filler used in the mixture and up to the point where the mineral filler actually reduces the percentage of voids in the total mineral aggregate a decreasing amount of asphalt should be used. Beyond this point, however, it is probably necessary to increase the percentage of asphalt due to the increase in surface area of aggregate to be covered.

A knowledge of voidage in the mineral aggregate is believed to be of great importance and general recognition of this fact with the development of a standard method for determining voids may lead to a radical modification in our present grading requirements for mineral aggregate which have always been of a more or less arbitrary nature. As a result of continued investigation on the part of a large number of testing engineers and chemists, coupled with service results, the writer looks forward to a time in the not far distant future when our present grading requirements will be simplified to such an extent as to cover maximum and minimum size particles with some intermediate limitation designed to control the size of voids coupled with a single requirement for maximum percentage of voids in the mineral aggregate.

The stability test which has been described is now being used to ascertain the actual stability values of compressed paving mixtures which have given satisfaction under known traffic conditions so as to establish a range of values which can be specified for mixtures to be used in future construction. In this paper it is only possible to touch upon a few of the high points of the research work that has already been accomplished in discussing the more recent developments in connection with paving mixtures. Definite recommendations based upon these researches are expected to follow as additional data is secured.

No paper dealing with latest developments in asphalt paving mixtures would be complete without some reference to asphalt base mixtures. The characteristics and use of asphaltic concrete bases or foundations were discussed to some extent in the writer's paper last year, so it is unnecessary to cover the same details at this time.

Asphaltic concrete "black base" as you know, consists of a mineral aggregate of approximately 68 percent of broken stone or gravel and 32 percent of sand mixed with about 5.5 percent of its own weight of asphalt cement. Both service results and field tests have demonstrated that such a mixture, when properly laid and compressed upon a good subgrade and covered with a standard hot mix top, is extremely durable and more resistant to traffic impact than an equivalent thickness of rigid base. "Black base" may be laid satisfactorily to any desired thickness without danger of breaking up under traffic if properly supported from below and may therefore be employed economically to reinforce an existing old road which it is desired to utilize for foundation. It may also be made to utilize local mineral aggregate to the maximum possible extent.

"Black base" has a service record extending over a period of more than thirty years and is used successfully under practically all climatic variations occurring in the United States, from Minnesota and Wyoming to Louisiana and Texas and from New York and Virginia to California. During the past three or four years asphalt base construction has increased rapidly in states east of the Rockies owing to its remarkable success in the far Western states which recently has been brought to the attention of

Eastern engineers. Last year California alone constructed about six million square yards of "black base" pavements, nearly 60 percent of its total of asphalt pavements laid during that year being of "black base" design.

One of the most recent developments in connection with "black base" construction which has been sufficiently tried out to warrant recommendation is the use of mechanical spreaders for distributing the hot mix. Mechanical spreaders may be used economically not only for spreading a uniform layer of mixture across the roadway, but for spreading narrow strips along the sides of old roads which are to be widened. In such work it has been found possible to spread as much as 400 tons of mixture per day with a force of only four shovelers and three rakers. A most interesting and instructive paper describing and illustrating the use of mechanical spreaders in "black base" work, by J. C. McLeod, division engineer of the California State Highway Department, was published in the June, 1925, issue of "Public Works".

While much more might be said at this time about "black base" the writer does not wish to digress from the subject assigned and in conclusion will state that in his opinion the most significant development in connection with "black base" construction in the East is its growing use as a means of salvaging old roads which have passed their period of serviceability as wearing surfaces and which are not sufficiently thick or stable to be utilized alone as foundations for new wearing courses. Such practice, if followed conscientiously, will save this country many millions of dollars which are tied up as an investment in old roads and which would be lost or thrown away if such roads were replaced with new construction entirely.

MANAGEMENT ON CONCRETE PAVING JOBS

By J. L. Harrison, Highway Engineer, U. S. Bureau of Public Roads, Washington, D. C.

(Paper read at 1926 Conference on Highway Engineering at University of Michigan, Ann Arbor.)

On paving work done in the Middle West, the commonly accepted working day is 10 hours—600 minutes. Management consists largely in making every one of these minutes count for something! Of course there are other elements in the successful conduct of a job. Good management for instance requires that the proper number of men shall be employed. It dictates adequate and proper equipment and eschews excessive equipment. It covers correct planning and requires that proper methods be practiced. All of these, with others of less importance, are parts of the general field of management, but at the moment it appears that of all of them the one most needing attention and yet receiving the least of it, is the proper utilization of the working day. In short, of the 600 minutes of working time that are by custom made available with the rising of the sun each week-day, a most astonishing number are, on most jobs, permitted to pass with no useful work accomplished. That this is true is totally a fault of management. Labor is not to blame. Neither can improvement be had by driving labor to greater effort. The problem is in no particular one of securing greater physical exertion from the men. It is totally one of securing greater mental effort from the management.

The studies which have been made by the Bureau of Public Roads during the past few years indicate that on the larger part of all concrete paving jobs, less than half of the 600 minutes daily made available are productively utilized. This will appear to many to be an astonishing statement, but it will be the purpose in what follows to show that this literally is a conservative statement of fact and to point out at least a few of the things that can be done to remedy this condition.

Briefly the bureau's studies show that time is lost in two outstanding ways, first through sheer laxity of administration, which results in starting late in the morning, stopping early at night, poor planning of operations with resultant lost time in moving, lack of a prompt attack of the work after rains, etc., and second, through low production when work is actually in progress. The bureau's studies of these phases has not been completed but Tables 1 and 2 are presented here to show something of the conditions which have been found to exist. Table 2 is particularly pertinent, for it shows data from a number of jobs in the middle west—all of the data relating to performance during the month of July. The region covered is the same general rain belt in Missouri and Illinois, and with due allowance for errors in giving the cause of

delays, the average loss of 20 hours because of excessive moisture is believed to be substantially correct. The bureau maintained a representative on one of these jobs during the whole of this month and his record of 23 hours lost from this cause adds confidence to the impression that these data are substantially accurate.

There remains, then, the fact that of the 2,000 hours available (a few Sundays were used on these jobs) 481 hours or 24 percent, roughly one quarter of the production time, was dropped outright through what appears, in large part at least, to have been managerial failure to keep the job moving. Managerial laxity of this variety varies in degree from those jobs where the standards are relatively high—in one instance it will be noted that the loss from this cause was under 10 percent—to those jobs where the standards are frankly low—the worst case here reported having been a loss of 120 hours through managerial laxity—nearly 45 percent of all the working time available during the month.

The discussion of lax management might be indefinitely extended but as work is still under way in this field probably it is more advisable merely to call attention to these losses, leaving a more complete development of their nature to some future time. However, it may be well in passing to refer again to the fact that the working day commonly contains only 600 minutes (though on many of the projects used in Table 2 as illustrations an effort was made to work longer hours). The function of management is to utilize these 600 minutes for production, and the conclusion is unavoidable that any effort at management which is so lax in its attention to the business-like direction of the work that large parts of the day are allowed to pass without even an effort at production will be conceded to leave much to be desired.

The second phase of this matter is the efficiency with which production is handled. Most specifications require that the batch be held in the drum one minute. A well designed mixer can, under these conditions, produce 48 batches of concrete an hour. There are mixers which, through faulty design, cannot accomplish this, but they need not be made the subject of special consideration here. A first class mixer can produce 48 batches of concrete an hour. This is the important point. Average production on the jobs for which records have been accumulated has been about 28 batches an hour. This represents an average efficiency of production while the mixer is in operation of something less than 60 percent. But as it has already been shown that nearly a quarter of the working day is dropped through managerial laxity, the unavoidable conclusion is that average production is well under 50 percent of what is attainable through high class management. To present a situation of this sort without an effort to offer a solution would hardly be helpful. As many of the gentlemen present are young men who look forward to earning their livelihood as engineers, it may not be inappropriate to suggest that in its essence the phases of management which are under discussion—often more specifically referred to as superintendence—are an engineering field. Just why the great universities have so commonly failed to grasp this fact and to prepare men specifically to fill this field is not at all germane to this discussion. The fact is, however, that the attainment of high production depends on a studious attention to the synchronization of all of the elements which taken together make up the production organization. It does not, in any large degree, depend on driving the men who work or even on a knowledge of how to handle men. The old time superintendent—more properly called the job foreman—can look after that part of the work and should be permitted to do so.

What the modern paving contractor needs is the services of a man who can sit quietly on the "side lines", study delays, ascertain their causes, determine the remedies and, through the application of these remedies, develop the production which should be obtained. Such men are all but unobtainable today. They can be developed and their services can be sold to any first class contractor. The work is practical engineering work of the highest type—the application of engineering principles to the conduct of construction work. It is a large and attractive field and both our universities and their engineering students should give it serious consideration.

But while in its essence the development of production on a construction job is an engineering undertaking, this does not preclude its frank discussion in terms that may be understood by anyone. The mixer is the primary producer on all paving jobs. The attainment of a proper output then, of necessity, means

that the primary producer shall produce the correct amount—the correct number of batches. Obviously pavement can only be laid as the concrete is mixed. There is, then, no escape from the fact that while it must be mixed as long as the specifications require, any extra time spent on this work, no matter how small, is a loss to the contractor. When the specifications require that the material shall be mixed for a full minute, the correct mixing cycle is 75 seconds. This will not be developed here. It has been developed in other discussions of this subject. (Those who desire a full discussion of this point are referred to "Public Roads," the official publication of the Bureau of Public Roads, for November, 1925. Copies may be had without cost upon request from the Washington office.) The point it is desired to stress here is that it is the duty of management to obtain this cycle. Extending this cycle by only a shade over 1½ seconds—losing only 1½ seconds on every batch—will cause the loss of a batch every hour. This is 10 batches a day—22½ lin. ft. or 45 sq. yds. of pavement (standard 18-ft. Maricopa section) which in turn is 30 sq. yds. of pavement for every second that the mixer cycle is extended. During a full working season —from 120 to 150 working days—the output of a mixer operated at high efficiency may easily be reduced as much as 4,000 sq. yds.—2-5 of a mile of pavement for each second added to the mixer cycle.

Now there is one aspect of this matter which cannot be ignored in discussions of this kind, namely, the fact that the paving crew and with it, of course, the payroll, is practically constant whether the production is high or low. A loss of time at the mixer is, therefore, a dead loss. On some kinds of operations the payroll can be reduced as production falls off. But on concrete paving work no such saving is possible, for paving has become a series of almost entirely mechanical operations and in such operations the force employed is dictated by the nature of the equipment rather than by the output which is being had.

On a concrete paving operation, the payroll commonly is not far from $200 a day and equipment depreciation is perhaps half of that amount. There are other items of lesser importance which might reasonably be included with these, but as the purpose is to show something of seemingly small repetitive time losses rather than to give definite cost data, and to illustrate a method of determining their importance, these will not be included. However, the two items which have been included, generate a daily operating cost amounting to about $300. If, now, instead of the correct mixer cycle of 75 seconds, the cycle is extended to 80 seconds, the output drops from 48 batches an hour to 45 batches an hour, or, in effect, 6¼ percent of the possible output is lost. But this does not change the daily payroll or the daily depreciation charges. The 6¼ percent loss in output is, then, equivalent to an equal loss of time and depreciation values or to about $19 a day which is nearly $4 for each second added to the cycle. Of course, the relative value of extensions of the cycle decreases as production falls, so that if the length of the cycle is doubled the loss is $150 a day and the value of a second added to or taken from the cycle then becomes only about $2, but whether operation is at a high rate of efficiency or at a low rate, every second is important, for in the first case the loss of a second on each batch, speaking in general terms, will cost the contractor from $500 to $600 during a full working season, while in the latter case it will still cost him from $250 to $300. There is here, then, ample reason for laying emphasis on the mixer as the point to be first considered in any effort to raise production to what, in fact, it ought to be.

The studies which have been conducted by the Bureau of Public Roads indicate that commonly the mixer is improperly operated. To obtain the correct mixing cycle it is necessary that raising the skip and discharging the batch be overlapped. The bucket must be dumped during the mixing of the succeeding batch, no batches can be split and the machine must be moved while it is mixing. Commonly, these are the points at which operators lose time. Occasionally the subgrade gives trouble. If it does, the operator can dump from the end of the boom, leaving a working space 10 to 14 ft. long next to the mixer in which the subgrade can be given the final finish, steel can be placed, parting strip laid, etc., while mixing is going on. This requires a little more frequent moving of the mixer—commonly after every fourth batch—but it can be done with no loss of time if the operator is at all proficient.

And in this connection it may not be out of place to observe that speaking

generally, operators have been found to be undertrained. Responsibility for this condition rests squarely on management. Production is one of the outstanding responsibilities of management and it can hardly be denied that if an operator lacks proper appreciation of the details of his work, it is the duty of the superintendent to make these clear to him. The proper operation of the mixer is not a difficult task. In fact, it is rather a simple one. But ordinarily it requires rather a set manner of operation, differing a good deal according to the style of the mixer, and unless the attention of the operator is called to those points in his style of operation which result in a loss of time, he is likely to know nothing of them.

While it should be obvious that full production cannot be obtained from a mixer unless the operator knows how to operate it correctly, it is equally obvious that full production cannot be obtained unless the supply of materials delivered to the mixer is both regular and adequate. The bureau's studies indicate that the material supply is quite as much a factor in under production as is poor operation. It will probably be admitted by both engineers and contractors that laying a concrete pavement is to be viewed as a series of successive related operations which, if full production is to be secured, must be carefully synchronized. It is this element of synchronization which today is lacking on so many jobs and its lack is perhaps most conspicuous in the material supply.

The correct mixer cycle has been given as 75 seconds—1¼ minutes. This is the controlling cycle on every well managed job and should be made so on every job. This, in turn, means no other single operation can regularly take over 1¼ minutes, for if it does it becomes the controlling cycle and production is reduced accordingly. Thus if, as has been occasionally found, handling the cement for a batch takes 1½ minutes, production is forced down to 40 batches an hour, no matter what the output capacity of other elements of the job may be. On one job visited during the past year, loading the aggregate for a batch had been taking an average of 3 minutes. Of course, while this condition persisted, production could not exceed 20 batches an hour. It is often found that an inadequate supply of delivery equipment—trucks—or the improper handling of this equipment had prevented the delivery to the mixer of more than one batch every 1½, 2 or 2½ minutes. A high rate of production is impossible where such conditions exist.

The recital of cases of this sort needs no extension to justify the statement that in every effort to build up production, a thorough examination of all of the operations on which production depends is necessary in order to determine definitely that no one of those subsidiary to the operation of the mixer itself is slowing up the job. With the exception of the actual transportation of the materials it has been found that the equipment on practically all of the jobs studied is adequate and that if a subsidiary operation is taking too much time, rather a brief study of this operation will reveal the cause and suggest a remedy.

Transporting materials from the material yards to the mixer offers more of a problem. This arises from the fact contractors are commonly under-equipped in this department of their work and obtain rather a low rate of efficiency in the operation of what equipment they have. To a certain extent this is due to the fact that the delivery capacity of various transportation units has been none too well known. It is also, to a certain extent, due to the same managerial laxity which has been found in other phases of this work. But whatever the cause, the effect is the same—a rigid limit on production. Until the delivery equipment is made adequate, full production cannot be obtained.

The problem which the contractor faces in obtaining delivery equipment is that the transportation requirements on his job vary sharply with the length of the haul. Thus, if full efficiency in their operation could be obtained, the delivery to the mixer of 48 batches an hour would require only 10 single batch trucks when the haul is one mile but when it becomes 5 miles, 36 trucks are required. Because the maximum haul varies so much from job to job contractors seem to hesitate to acquire all the trucks they ought to have, fearing that the next job may leave on their hands large numbers of trucks which cannot be used. This is not an altogether unsound attitude but the investigations of this matter which the bureau has made seem to indicate that a contractor may properly purchase trucks in such number as are needed to handle the average maximum length of haul generally prevailing in the region where he is operating. If, after having

equipped himself in this fashion, work is obtained which for its efficient conduct requires a larger truck supply, the additional trucks should be hired for short periods when the length of haul is such that they are needed.

It is, however, one thing to have enough trucks and quite another to use them efficiently. The formula commonly applicable to the operation of single batch trucks is: T (the round trip time in minutes) equals 8d (d being the distance from material plant to mixer in mlies) plus 4. Formula for other types of trucks are given in December, 1925, issue of "Public Roads." The haul distance at any time is, of course, known. As an example, assume for the moment that the haul is 1.5 miles. The trip time for single batch trucks should then be 8 times 1.5 or 12.0 plus 4, which is 16.0 minutes. In a ten-hour day there are 600 minutes, so each truck should deliver 600 divided by 16 batches which is 37 batches. If the mixer is operating at the rate of 46 batches an hour—460 batches a day—13 trucks will be needed and an extra truck may well be supplied in order thereby to avoid the effect of the numerous small delays that are encountered under even the best supervision.

The constant 4 which appears in this formula, covers the time commonly required to load aggregate, to move to the cement shed and load cement, to get back to the road and, at the site of the work, to pass through the turntable, including extra time consumed in backing from the turntable to the mixer, and necessary delay at the mixer. While these operations ought to be performed in four minutes, often they are not. One job was studied during the past season where operating practices including stops to water the trucks, to take gas, to take oil, to make minor adjustments, etc., actually extended the time required for the various services—the constant—to about 10 minutes. Trip time on a 1.5 mile haul was, by these practices, extended to 22 minutes which had the effect of reducing the number of loads carried per day to 27, a reduction of operating efficiency to about 73 percent. This was rather an extreme case but operating practices that lengthen the constant are common enough.

Bunching the trucks has much the same effect. If a number of trucks come into the material yards together there is delay in servicing all but the first. The general effect is to increase trip time.

Slow driving is not of common occurrence but the effect is also to increase trip time and so to reduce the number of batches delivered.

Other elements in the situation could be enumerated but it is hardly necessary to do so, for the purpose is merely to draw attention to the fact that having a full quota of trucks does not mean the delivery to the mixer of an adequate supply of materials. The trucks must be managed correctly if a full material supply is to be had.

Something has been said of the fact that contractors commonly are underequipped on the transportation side of their work. It may seem a bit ridiculous to add that often too many trucks are used but this literally is the case. This comes about from the common tendency to maintain a constant truck supply. The truck supply available is, let us say, capable of making full delivery up to a haul distance of 2½ miles. Haul beyond that distance is performed with an inadequate truck supply which results in a low rate of delivery as described above. Then, when the haul falls below 2½ miles no change is made in the number of trucks used as the haul decreases with the result that the truck supply becomes excessive by increasing amounts. This is, of course, an outstandingly bad operating practice and appears to be one of the causes that have led contractors so generally to conclude that trucks can be hired at a price that is below the cost of owning and operating them—a most fallacious conclusion.

These are only a few of the matters which might reasonably be touched on in a discussion of this kind. The subject is a long one—far too long to treat adequately in an address of this sort. For that reason, aside from the effort which has been made to invite your attention to

TABLE I

Average output per hour of mixer operation	70.8 ft.
Average number of hours mixer operated on days it worked	8.0 hrs.
Average number of batches placed per working hour by mixer	28 approx.
Average efficiency of mixer	60% approx.
Total number of hours mixer operated, all jobs 1925	6,981 hrs. on 874 days
Total number of hours lost by mixer, all jobs 1925	5,719 hrs. including 307 full days
Average length of attempted work day, all jobs 1925	10.8 hrs.
Total lineal feet of pavement placed, all jobs 1925	494,211 ft. by 16 mixers

TABLE II

Job No.	Mixer Operation Working Days: No Work	Less than 5 hrs.	5 to 10 hrs.	10 hrs. or more	Total days Worked	Total hours Mixer in Operation	Total hours Mixer Idle	Length of Working Day hrs.	Linear Feet of Pavement Placed	Aver. Lin. Ft. Placed per hr. Mixer Operated	Aver. hrs. per Working Day Mixer was in Operation	Hours Lost Because of Rain and Wet Subgrade	Mixer hrs. Lost Other Causes than Rain and Wet Subgrade
*1	1	1	11	14	26	232	65	11	17,635½	76.3	8.9	23	42
*2	4	2	13	8	23	198½	87½	11	13,956	70.3	8.6	17½	10
3	1	3	6	17	26	225	45	10	21,564	95.7	8.7	18	27
4	3	2	8	13	23	212½	74½	10 to 13	12,451	58.8	9.2	46	28½
*5	7	2	16	2	20	155	142	11	14,441	†93.2	7.75	22	120
*6	5	3	19	0	22	165¾	104¼	10	14,570	†88.0	7.5	....	104¼
7	5	1	10	10	21	186	99	11	13,839	†74.3	8.9	10	89

* One Sunday worked.
† Six-bag mix used in a five-bag mixer.

some of the more important aspects of this outstandingly important matter, the management of paving work, it has been the purpose to leave with you a new view of management—a view of it as a study—a technical field of outstanding attractiveness. It is not an art which may be learned, for every job offers new problems which can be solved by no rule of thumb. It deals little with the supposedly important matter of "getting a full day's work out of the men" but very much with getting full production out of the entire outfit. In its every aspect it is as much subject to the application of well defined laws to specific conditions as is the design of a bridge or the calculation of stresses in the columns of a building. These laws are, perhaps, not quite as well worked out as they are in the field of design, but they can be worked out and they can be applied. But in their application men with a technical training are needed and it is confidently predicted that the laws governing management in this work will not be properly applied until such men are aavilable.

THE CITY MANAGER PLAN IN 1926

By Harrison Gray Otis, City Manager, Clarksburg, W. Va., President International City Managers' Association

Eighteen years. Henry was poor. Radio and Volstead were unknown. Wilhelm lived at Potsdam. Women neither voted nor bobbed. There was no air service to dispute. All of which means that eighteen years is quite a while these days. The manager plan is no longer new.

Born in Virginia, weaned in South Carolina, christened successively the Staunton plan, the Lockport plan, the Sumter plan, the Dayton plan, but becoming most widely known under the euphonious misnomer, "council-manager" plan, the young movement was schooled and spanked in a score of states and fondly nurtured by the late lamented National Short Ballot Organization, the American City, and the National Municipal League.

An Established Institution

Today the city-manager form of government is an established institution in America and is making headway in Canada and New Zealand. Approximately 360 municipalities, serving over seven and a quarter million citizens, are operating under, or pledged to, some variety of city-manager government. It is a vigorous youth, with many achievements to its credit. It faces a career of service with a great uncharted field ahead. However, at this dawn of manhood, a sizing-up of assets and liabilities, a checking of errors and a bit of friendly counsel, appear timely.

No Longer a Novelty

First of all, the period of coddling is past. The apron strings are broken. The movement can no longer look to the kindly propaganda of its erstwhile sponsors and tutors. It is fledged. The further growth of the city-manager plan depends upon its own record, the initiative of its own household, the success of those cities now flying its banner. Being no longer new—it no longer attracts by a mere magnetism of newness. A city's adoption of a manager charter is only local news now unless the recruit be noticeable because of size. The fad stage has passed. New laurels must come from merit only—not from novelty.

Diseases of Childhood

On the other hand, certain diseases of childhood are no longer to be feared.

The attacks are less frequent and less liable to be fatal. Among these ailments, which at times were epidemic, a few may be cited.

The whooping cough of propaganda is nearly over. The plan is no longer painted as a panacea, a cure-all—a gateway to the millenium. The adoption of the manager form, in and of itself, is now recognized as only the first step toward good government.

Scarlet fever, or the charge that the idea is ultra radical and sure to mean a dictatorship, has likewise developed an immunity, as people find that only good old American principles are involved.

The mumps—or cases of enlarged importance to individual managers on the one side and certain groups on the other, are yielding to the treatment of time. It has been demonstrated that the movement is greater than any of the men engaged in its advancement and that successful managers may come from most unexpected sources. Also that a good manager is not much good with a reactionary council or a faulty charter.

The Follies of Youth

Then there are the follies of youth to be considered. We may not all agree upon the definition of folly, but experience seems to point out certain weaknesses that time should eradicate.

Richard S. Childs, to whom the movement is more deeply indebted than to any other one man, made a most illuminating little talk, after a good dinner, at the Washington meeting in 1923. It might be called the confessions of a publicist. You see, it was Dick who introduced the manager idea of Staunton to the commission idea of Galveston. Out of the union that followed, came first the stillborn Lockport plan, and later, the Sumter charter. True it is that A. V. Snell, then secretary of the Sumter chamber of commerce, has claimed the distinction of being the Sumter matchmaker, but history will always honor Dick, who certainly became godfather to the foundling and sat in at the several christenings.

Now as to the "confessions." The tenth yearbook calls them "very interesting," but does not publish them because of their confidential character. Ah well, what are a few confessions between friends? Anyway, I haven't heard from Mr. Childs for a long time—I may soon.

"Commission-Manager" a Misnomer

Here goes. It was Dick who named the child in honor of its parents, calling it the "commission-manager" plan. At first he even sanctioned the title appearing on the early literature of the National Municipal League. "The commission plan—with a city manager." The purpose was twofold: to assure a small, nonpartisan council, and to capitalize on the popularity of the then growing commission form.

These two objects were laudable and the title served the purpose well. The folly came in the public's crediting the child with too many of its mother's traits. The fundamental ideas of the old commission form and the modern manager plan are strongly divergent. Yet many charters ape the older form to the serious handicap of the newer. The success of the manager plan lies very largely in divorcing the council from all administrative duties and giving the manager pretty complete authority and responsibility to carry out the policies of the council, without too much interference on the part of individual members of his council.

Adoption by Ordinance Unwise

Another folly may be credited to the paternal side of the original alliance. Staunton adopted the manager plan in 1908, by ordinance only. The handicaps developing, drove the first manager to resign after three years' service, and were later rectified by adoption of a standard charter. However, many cities have since tried the same experiment—local ordinance instead of charter. Fully one-third have given up in disgust. Several have advanced to the charter form. A very few have succeeded—largely because of favorable local conditions and lucky appointments.

A third error, creeping into a few charters, is the insistence that the council be limited in its choice of manager to local applicants only. I know of no such city which has made an outstanding success. Many of our most able managers are local men, but they won their position in competition with all comers and not because the field was limited to home products. Partisan and ward elections are features still found in some of the older charters and have been the source of many fusses and fizzles.

So much for some of the mistakes. Here are a few of the elements of strength with which the manager movement faces the new year:

Cleveland Charter a Success

The plan is a success at Cleveland. A

second council has been chosen. An attempt to change the method of voting has been defeated. A creditable record has been set up by the administration.

The overwhelming vote by which Cincinnati and Rochester ousted old political regimes by adopting thoroughly modern manager charters, denotes the growth of public confidence.

The final victory of the manager advocates at Kansas City is clouded only by the possibility that party politics may still control the government and handicap the efficiency of the new charter. Kansas City has a great opportunity to become a leader in municipal progress. We hope for the best.

Proportional Representation Gains

The increased use and apparent success of proportional representation are noteworthy. A council more largely representative of the whole citizenship is a big need in most cities. The old game of "outs and ins" is always a handicap to the peace and progress of city affairs.

The increasing tendency of cities to seek executives of special training and experience is encouraging. More than a hundred promotions from smaller to larger cities have already been recorded.

Opportunities for specialized training in public administration have been increased. Syracuse has opened up a million dollar school of citizenship and public affairs. Michigan and California are continuing to develop good men. Other schools are offering special courses.

Code of Ethics Effective

Professional ethics are becoming crystalized. Several cases of sticking to the principles of our code in the face of grave obstacles have strengthened our whole calling. And lastly, the growing size and service of our association are cause for optimism. It is trite for a president to call upon members for cooperation—hence I refrain.

Forward Step in Human Progress

Here's my message: Get a vision, fellows. Get a vision.

Look upon your job as a career—a chance for service—a part of a great forward step in human progress. Get away from the idea that you are buying personal benfits with your dues. Get behind the association. Make it the lens through which the little light you may be fuelling can shine the farthest and do the most good.

And you newcomers: Forget your cinders, sewers and sidewalks a moment. Your corporate bounds may mark the limit of your jurisdiction, but through the association, the four corners of the earth are outposts of your bailiwick. The next election may be the end of your term, but Gabriel alone will sound taps on your influence, if you put forth the best that's in you during 1926.

ASPHALT MACADAM IN NEW YORK AND NEW ENGLAND

By U. L. Ostrander, Eastern Branch Manager, The Asphalt Association, 441 Lexington Ave., New York, N. Y.

(A paper read at the 1926 meeting of the New Hampshire Good Roads Association, Manchester, N. H.)

One half of all the bituminous macadam in the United States is found in New York and New England. The combined mileage of this type on all of the state systems of this country is approximately 9,000 miles, while over 5,500 miles are in this group of states, with over 4,000 in New York alone. The cities of the whole nation show some 33 million yards of the type. New York and New England cities have over 16 million yards of this total. These figures do not include waterbound macadams, with or without bituminous surface treatments, but include only the bituminous bound macadam built by the penetration method. While exact figures are not available to show the proportions of asphalt macadam and macadams bound with other bituminous materials, it is not an exaggeration to say that the asphalt types bear a ratio of ten to one in past construction and even greater in present practice.

It is looked upon with nearly as great favor for a large percentage of city streets as on the open highways. It admirably serves the early pavement needs of those streets which require a surfacing but upon which traffic has not yet become so intense as to justify a more expensive type. In Boston 55% of all the streets better than gravel are some form of macadam. Springfield, Mass., shows the same percentage—55. Providence shows 70%, Portland, Me., 39%, New Haven 33%, and New York City 17%. In these cities where some of the older macadam had not originally a bituminous binder it has, in practically every case been treated with bituminous surfacings. Present practice in macadam is the bituminous penetration type exclusively.

When asphalt macadam first came into use on a scale worthy of mention along about 1908 to 1910, New England and New York had for many years been placing waterbound macadam rather extensively. They had thus been initiated into many of the fine points necessary to be observed to secure durable pavements with a long smooth life. So that a considerable degree of success was attained from the very beginning. That this is true is best attested by the fact that many miles of these earlier penetration asphalt macadams, built in the years 1909-1910-1911, are still carrying their original surface even though they were designed with extremely light foundations, as we would consider them today.

In New York state, of the 9,800 mileage of paved roads already built on the state system, a great frame work of over 4,000 miles is asphalt macadam, largely with its original surfacing, and with an average age of ten years. This means some of these roads are 14 or 15 years old. This age would not be considered remarkable for pavements built under modern specifications but I recall that at the time these roads were built the usual base placed under them was only a 3-in. or 4-in. thickness of broken stone and motor trucks were non-existent. They were placed on new roadbeds which had never before been metalled. Their extent is so great as to cover all kinds of soil and drainage conditions.

The mileage in New York state is made up of a vast network of interconnecting roads. However, one long arterial route seems to deserve especial mention. One can start at Saratoga Springs, in the south foot hills of the Adirondacks, and travel north, through Lake Champlain, Ausable Chasm to the Canadian line, and thence along the border through Ogdensburg and the Thousand Island territory to Watertown, encircling the whole of the Adirondack mountains and riding all of the way on bituminous macadam. The route is over 400 miles in length and the mileage other than macadam is insignificant. Most of the pavement is 10 to 15 years of age, and is in such excellent condition today that the only portion scheduled to be advertised for resurfacing during 1926 is not of the macadam type.

Present foundation practice in this section seems to be fairly uniform among the various states. As a rule, in entirely new construction, a foundation course of 8 to 10-in. depth of sledged stone or telford is placed by hand and filled with a good grade of gravel or broken stone. Every effort is made to secure a smooth, true surface, with voids well filled. Sand or cinder blankets are growing in favor over soft subsoils to prevent the separation of the stones of this course through the working up of soft materials into the course. Where careful attention has been paid to occasional pockets of soft or spongy material, failures have been practically eliminated. Under especially unfavorable conditions the foundation depth is frequently increased to 12 ins., and usually placed in two courses. Frequently the additional bearing power is secured through the use of a subfoundation of selected gravel in localities where suitable material is available.

Over this foundation the accepted present practice is to place a 2 or 2½ in. course of broken stone, to insure permanent filling of the voids in the foundation, to give a greater uniformity of surface to receive the penetration course, and to add strength to the section through the use of a small quantity of material most valuable for this purpose. The depth and sizes of stone for this course are varied to suit the particular condtions of the project, the intention being to use all the crushed product not required in the other course. Where the stone is not crushed locally, 2½ to 1½ size is generally used. The voids are filled with stone dust, clean sand or fine gravel. An excess of filler is not desirable and, in fact, better results obtain where the stone of this course is exposed for about ½ in. The filler should be dry when applied and should be put on in several light applications to insure a proper sifting down into the lower voids.

A thorough rolling of this course as well as the foundation course is essential. While there is some difference of opinion among experienced builders as to the advisability of full rolling on all kinds of stone in the penetration course, there is no doubt whatever as to the necessity for a most thorough consolidation of the lower courses. The possible breaking up of softer grades of stone has no harmful effect.

It is sometimes preferable to use a base of penetration macadam instead of the crushed stone base with stone filler. Such a treatment is most effective in resurfacing on old macadam or gravel road bed which has been consolidated to the utmost through years of travel. These beds may need strengthening or

simply to have their crown reduced. In either case it is preferable to use the more substantial penetration course between the hard old base and the new surface course than to introduce a comparatively soft or loose course between the two.

The penetration course as built in these states varies in several ways. The best results seem to be obtained through the use of 2 or 2½ in. depth of finished course rather than with 3 ins. or a greater depth. There seems to be less tendency toward displacement. Certainly it is possible better to fill the voids in the thinner course. The screen sizes vary from 2 to 2¾ ins. maximum to 1 to 1½ ins. minimum, the best results being obtained with the sizes 2½ to 1¼ ins. for hard stone, slightly larger for softer field or wall stone. The manipulation of this course varies in different sections and with different grades of stone. The result desired is a strong interlocking of the fragments. With a hard trap this can only be secured through considerable rolling before the first application of asphalt. But softer grades of stone will interlock under less rolling, while to continue to roll them at this stage will often crush the fragments to such an extent as to make proper penetration of the binder impossible. Regardless of the quality of the stone, a thorough rolling after completion of the pavement is always desirable. This back rolling should continue for several days during the warmest hours, and under traffic if practicable.

The thickness of the course spread loose should be the size of the largest screen opening. The stone should be spread to a tight line on pins not over 25 ft. apart. Roll enough to smooth out so the high spots may be seen. The high spots will usually be due to too many large stones while the low spots will result from an excess of small stone. Transfer some of the large stone to the low places and some of the smaller sizes to the places where the large sizes were taken out until the stone look uniform. Then roll again and take another look before pouring.

To get good results, the surface must present as nearly as possible a uniform amount of voids. The stone ought not to be rolled so tightly as to retain any surplus asphalt on the surface. After the first pouring cover quickly with clean pea stone and roll in order to stick the pea stone into the hot asphalt. Roll only lightly unless the road must be opened to traffic before the seal coat is applied. If so, use more pea stone and roll tight. Later sweep off surplus pea stone and apply seal coat, more pea stone and give a thorough rolling. Do not allow traffic ahead of the seal coat if it can possibly be avoided. And do not neglect thorough back rolling after all materials have been applied.

A road built this way will have a toothy surface when the surplus pea stone has blown away and will retain this fine driving surface if pea stone and not too much bituminous material are used in maintaining it. Do not expect to get a good job unless the voids in the top are uniform before pouring. Don't expect to get a good job if there are large areas more than one stone thick. Stone must be clean and free from mud or dust. Stone for cover larger than ¾ ins. are too large and too strong to go into the voids without wedging apart the stone already in place. Surplus sizes of stone should be used in foundations or on shoulders and all stone should be paid for by weight. In applying the asphalt 40 to 50 lbs. pressure is about right and the temperature should be 330 degrees F. More trouble will be experienced with low temperature than with low pressure.

After the first application of asphalt, the Massachusetts practice is to use a smaller keystone than is specified in Rhode Island. This stone in Massachusetts is ¾ in. to ¼ in., and the same size is used to cover over the seal coat of asphalt. The Rhode Island practice is to use a keystone from a 1 in. to ⅝ in. size as filler for the penetration course, while for the final cover stone a ⅝ in. to ⅜ in. size is used. In both states careful attention is paid to uniform distribution of this stone and the removal of any excess. This is essential if a riding surface that will stay smooth is to be secured. Uniformity is a prime requisite in this type as in most others. To secure uniform penetration from uniform pouring, it is necessary that the surface voids of the rolled course be uniform. This is not difficult of attainment if its absolute necessity is kept in mind.

In Massachusetts the first application of asphalt is 2 gals. per sq. yd. for a 2½ in. course and 1¾ gals. for a 2 in. course, either being followed by a ½ gal. seal coat. Rhode Island pours 1¾ gals. first pour followed by ¾ to 1 gal. seal coat. The effect of these differences in sizes of keystone and rate of pour becomes

evident after two or three years' service. The Massachcsetts macadam is slower to fill to a smooth sheet-like surface. It remains toothy with the stone showing appreciably for several years longer period than is true in Rhode Island. These states are mentioned as theirs is the typical practice throughout New England, a practice which has secured most satisfactory results over a long period of years under traffic conditions that compare in severity with any that exist in a like area.

Rhode Island claims more motor cars per mile of highway than any other state in the union. It is reasonable to presume that her highway traffic averages quite as high. Also, as the state is highly industrial itself and is situated in a highly developed area, the percentage of trucks, particularly heavy trucks, is large. The 1924 traffic count figures for Massachusetts show a daily average per station for the whole state of 3,721 vehicles with a maximum daily average of 17,715 vehicles, with 9 percent trucks and buses. While the average figures for Maine are smaller, 1,269, the distribution of traffic is less uniform, giving high maximums for many individual routes. Their opinion of the adequacy of the type is reflected in the recent statement by the Maine commission: "On the basis of Maine construction and maintenance experience, it is believed that bituminous macadam, of the type now being constructed in the state of Maine, will adequately serve the present and future traffic on these highways (referring to a large part of their primary system) for the expected life of the bituminous macadam type of the construction." Also Maine reports state: "***** traffic is being carried on the bituminous macadam roads at a cost of 1/6 as much per vehicle mile as on the gravel surfaced highways." Massachusetts in 1925 awarded about 72 miles of the macadam type, just four times the mileage of the next highest, which is asphaltic concrete, with 18 miles. New Hampshire figures shows the same predominance.

In New York state, construction details have been different from the New England practice. Recently changes have been adopted to bring the work more nearly in line with the others, so that now the greatest difference lies in the hardness of the asphalt binder. New York, which for many years has used 120-150 penetration material, has recently changed to the 100-120 grade while the New England states specify 85-100 material. Also New York has built nearly all of her roads with a 3-in. top course, and with asphalt pours of 2 gals. or less for both applications. While the New York roads are most of them high class roads their excellence has been secured at a higher maintenance cost than is necessary for the type. For instance, while Massachusetts seldom oils an asphalt macadam sooner than 7 or 8 years after construction, with an average of about 12 years before such a treatment, New York state averages such a treatment every third or fourth year. If one looks at the map of Massachusetts one will see leading north from Boston a long perfectly straight route toward Portsmouth, N. H., and the Maine coast. This is the famous Newburyport Pike 25 miles long and the most favored route for reaching the beaches and shore resorts as well as the most direct trucking route from Boston into Portsmouth and the Maine cities. It is largely asphalt macadam, some of it 14 years old, none of which has ever been treated with one drop of oil. The same condition obtains on the heavily traveled east and west route between Boston and Worcester. In view of the results secured in Massachusetts it is evident that the construction differences which make fewer surface treatments possible without adding to the cost are most desirable. New York state has been spending from 1 million to 1½ millions dollars yearly on this oiling work, showing that the possible savings mount to a considerable figure.

I dwell at some length on this surface treatment phase as it is one of the misunderstandings which have ruined many a good road, have caused the waste of millions of dollars and has been held up as a nuisance bugaboo by inexperienced highway officials and others against a much wider adoption of the macadam types.

Foundations for asphalt penetration macadams not only play an important part in the success of the pavement but their development is of interest. Early foundations were light, in keeping with general construction of the time, usually 3 or 4 ins. of coarse crushed rock, with the occasional strengthening of additional gravel. The use of gravel without a crushed rock cover was tried but generally found unsuccessful unless the gravel was of exceptional quality. With increasing weight of traffic, heavier foundations were seen to be necessary and an at-

tempt was made to use a base of large stone, of say 8 in. greatest dimension, to give a greater depth of base but at a cost lower than possible with crusher product. The earlier examples were built without especial attention to the grade of filler for this course with no intermediate course between it and the penetration surface course. The result was, that with soft filler frequently used, the top course stone would soon be pushed down into the larger voids of the foundation stone leaving an uneven surface. This roughness was two or three years making itself apparent so that a considerable mileage of road had been completed before the specification was improved. The requiring of screened gravel or crushed stone filler, together with an intermediate crushed stone course has corrected this difficulty. The depth of this large stone base course is now generally 8 ins. minimum. There are locations where the available material is hard roundheads, many of a size ready for crushing but too large for base course where I believe a less depth, say 6 ins. of crushed rock, would make a better foundation at less cost than the sledged stone with proper filler and leveling course.

There has been a limited yardage of asphalt macadam placed over Portland Cement concrete foundation in this section. Some of this was so designed originally, while in some cases the surfacing was placed as soon as it was realized that the concrete was unfit to serve longer as a surface. These foundations were usually 4, 5 or 6 ins. in depth, 1-3-6 or 1-2½-5 mix, and sometimes of gravel aggregate. The results have been satisfactory. I recall two instances in central New York which have 4-in. gravel concrete bases, pitrun aggregate, about 1-2½-5 proportions, with 2½ in. asphalt macadam surfacings. These were laid in 1912 on the main streets of villages on through routes and are now in most excellent condition, with practically no repairs. Certainly, here the asphalt surfacing has extended the life of this concrete many times its natural life if left uncovered.

Chautauqua County, New York, is spending several million dollars on her county system of highways in addition to the state mileage in the county. Suitable local stone is not to be had. Their gravel is not sufficiently clean for hot mixed surface. However, her road building is in the hands of people of long experience in the construction and maintenance of high class pavements who realize "there are many ways of skinning a cat." They use a 12 in. compacted depth of local gravel, placed in two courses for a foundation. Over this is placed a 4 in. compacted depth of crushed blast furnace slag, this being the cheapest material of the sort to be had. This is followed by a 3 in. depth of penetration asphalt macadam of imported limestone. The whole cost of these 16 ft. wide roads, 19 ins. deep, with a large portion of imported materials, and through terrain requiring about 7,000 cu. yds. of grading per mile, averages between $20,000 and $25,000 per mile.

These same people have gone a long ways toward finding a suitable means of carpeting Portland cement concrete pavements that have begun to fail through disintegration or shattering. In Chautauqua county and the territory immediately adjacent, the state has more than a hundred miles of Portland cement concrete pavements now requiring resurfacing if they are to be salvaged as foundations. In an effort to hold them together until such time as funds are available for placing hot mixed tops, thin asphaltic surfacing has been placed. After much experimentation excellent results are being secured through the use of a surface treatment of asphalt cut-back of about 35 percent distillate and 100 penetration residue. Two applications of ¼ gal. each are given, each followed by the rolling in of all the ¾ in. stone the cut back will carry. This treatment has been tried out over many miles of Portland cement concrete and is giving lasting results.

Throughout the greater part of New England it is considered essential that high quality, hard, tough stone only should be used in the wearing course of asphalt macadam. In many sections it is necessary to import such stone as the local stone does not qualify. While I would hesitate to criticise any leaning toward higher class construction, I feel that many times proper manipulation of the stone and selection of the binder will give first class results with stone of a softer nature. Such stone should not be rolled more than enough to lock it together and smooth it out before the first application of asphalt. But it will withstand and it should have, a thorough back rolling after all the materials are in place. Also the sizes should be larger, and the manipulation should be such that the stone is not left exposed to wear and

impact, but traffic should be carried on the asphalt and stone dust matrix. With this method, good results will usually be obtained automatically through the use of a soft stone if a reasonable quantity of asphalt is poured. Also a softer grade of asphalt will work better to pick up any broken fragments of rock. I have seen instances of such work in which there was used comparatively soft, thinly-laminated sandstone or loosely bound granites and that are affording excellent riding surfaces after ten years' service. Apparently they are good for many years yet. One such example is immediately adjacent to high grade crushed trap surfacing with identical traffic, soil and base conditions and presents just as excellent a surface and is, I believe, quite as satisfactory for the traffic imposed as the more expensive road of imported materials. I cite these opinions not with a desire to advocate lower standards of construction but once more to emphasize the adaptability of many kinds of local materials to some type of pavement with fair assurance of success. The savings that are possible frequently run into totals so large as positively to demand their acceptance.

In the Catskill and Adirondack mountain sections remote from railroads as well as in some of the southern sections of New York state, and in many sections of New Hampshire, Vermont and Maine, savings of more than $10,000 per mile may frequently be effected through the adaptation of the type to the materials at hand, and yet give a perfectly satisfactory pavement. For the asphalt macadam type usually the only material requiring importation is the asphalt and that only to the extent of about 120 tons per mile. While the difference in this item is slight for the mixed asphaltic types it is tremendous with any other type, running as in the case of Portland cement concrete, from 900 tons where only cement and steel are imported, to 2,600 tons per mile if sand also must be brought in, and to 5,300 tons per mile if it is necessary to import the stone. Not only does the cost of freight and haulage run into an extravagant item without adding in any way to the value of the materials but it unnecessarily obligates the employment of a considerable number of men and hauling units that might well be used for other work. A still greater reason for avoiding this hauling is the wear and tear unnecessarily inflicted upon the roads intervening between the construction work and the delivery point at railroad or dock.

Construction costs vary with the locality, material, width, thickness, etc., as well as between original construction and resurfacing. In New York in 1925 the average cost per mile was 32,000 for heavy reconstruction work. In Massachusetts $45,000 per mile is given as the average, Rhode Island reports an average of $31,375 per mile for the past nine years' work, while Connecticut reports $23,200 for 1924. Recent maintenance costs are available only from Massachusetts which gives $.03¼ per sq. yd, and from Rhode Island which shows $.022 per sq. yd., or $232 per mile of 18 ft. road. The latest published figures from the large mileage in New York state are for the year 1922 and they show a maintenance cost of $455 per mile for asphalt macadam. For the reason we have already mentioned—i. e., excessive oiling, —this figure is unnecessarily high. Also it must be remembered that these roads are old roads, averaging 10 years of service and were built before we realized what traffic was in store for them. There is no good reason why New York maintenance costs should be higher than Massachusetts or Rhode Island.

Maintenance costs of all kinds of pavements are the subject of much discussion nowadays, but few analyses give proper recognition to depreciation. This item, together with interest charges, form the bulk of the highway expense with maintenance charges playing a comparatively small part. This is especially true in comparing the usual hard surface types now being considered for our better roads.

Fifteen to twenty thousand dollars per mile difference in construction cost is a usual figure between some of the types. On the basis of a $15,000 difference in first cost, with a 15 year serviceable life, the difference in interest and amortization charges between the two kinds runs up to $1,350 per year. So a difference in maintenance cost of one to two hundred dollars per year, or even an outside three hundred, does not change the result very much.

It would not be proper to conclude without some special mention of the possibilities of gravel in high class construction, especially here in New Hampshire where such excellent gravel abounds. There are two outstanding methods of utilizing this material in asphaltic work. One for carrying the lighter traffic is the asphaltic oil sur-

facing that is giving such excellent results on thousands of miles of road under traffic as heavy as on 90 percent of the New Hampshire mileage. This surfacing requires a minimum of renewal for its kind, say every three to five years, and makes a wonderfully effective and inexpensive method of salvaging some of the more cheaply constructed waterbound and gravel roads where the raw surface will no longer suffice. The other gravel type is for any traffic that will come. It is the hot mixed graded asphaltic concrete. In sections where reasonably clean gravel is found this pavement may be placed for considerably less cost than any of the other good types, will handle any traffic with a minimum of repair and has the usual asphalt advantages of durability, waterproofness, ability to absorb shock, resilience and fine appearance. There are many hundred miles of this in New England territory and New Hampshire is getting her share.

RECENT DEVELOPMENTS IN HIGHWAY BRIDGE ENGINEERING

By J. R. Burkey, Chief Engineer of Bridges, Ohio Division of Highways, Columbus, O.

(Paper read at 1926 Mississippi Valley Conference of State Highway Officials at Chicago.)

The subject assigned is a very broad one and so comprehensive that the best I can do is to set forth and emphasize those features in the recent developments of highway bridges which in my judgment are the most outstanding.

In surveying the subject, it seems fitting to take up Developments in Specification, Design, Construction and a few important details. It seems desirable not to enter into a technical discussion of bridges but rather to deal with matters of concern to administrative officials such as most of you are.

Taking up specifications, it is interesting to note that until quite recently very little recognition was given to the twofold purpose of a bridge, namely that of providing for traffic over it, and for water under it. I believe that Ohio was one of the pioneers in giving that latter thought prominence in its specifications, it having had a forceful reminder in the devastation resutling from the 1913 flood. It is especially important in State work, for in connection with new improvements, highway grades are often changed so radically on approaches to bridges that a structure under the new conditions may have to take care of much more flood water than it did with the old low-lying approaches. On the other hand many instances arise where a survey of the stream at some well defined section, or perhaps a careful study of the topographic maps of the U. S. G. S. will disclose the fact that an old bridge is much larger than needed. With our varying conditions of climate, topography and soil, it is quite difficult to get a specification of general application, but it is at least gratifying to know that this problem is receiving more intelligent attention.

Another phase of the bridge problem in which the administrative officer is interested is the width of roadway. The tendency unquestionably is toward wider bridges. Some 15 years ago, I helped start the first Bridge Bureau in the State Highway Department of Ohio. For the first two years, according to the laws then in force, we were required to prepare plans and estimates for the bridges, and the contracts were financed and awarded by the County Commissioners. These officials were not accustomed to improved highways and we had difficulty in promoting wide roadways at that time, in fact we must admit that our own ideas in those days, have since been proven too short-sighted. We cannot censure anyone for not foreseeing then the future traffic problem, when we recall that at that time our illustrious Governor Harmon, a man of vision and large affairs, in urging highway improvement, predicted that he might see the day when 50,000 automobiles would be using the highways of Ohio. Now Governor Harmon was a healthy man when he made that statement, in fact, he is yet today, and our records indicate that during this year about 1,500,000 motor vehicles will be registered in our state.

Most progressive states have adopted 18 ft. as the minimum width of pavement on their state system of roads. For the sake of its own safety and that of the traffic on it, a rural bridge should have a roadway considerably wider than the pavement on its approaches. Furthermore, past experience has shown that as years go on we are forced to widen our old pavements. This can usually be done without sacrificing on our original investment, but in the case of bridges, we are not so fortunate; in fact it too frequently happens that when an attempt is made to widen them the

original outlay is a total loss. As to comparative cost, our records show that for average conditions a 24 ft. roadway can be built for a total cost of from 10 percent to 15 percent more than that of a 20ft. roadway, depending upon the type of bridge and the height of the substructure, whereas the increase in available roadway is 20 percent.

On the state system in Ohio practically all of our rural bridges on tangents are being built with a 24 ft. roadway. Extra width is provided on, or adjacent to curves and in built-up communities. In the latter instance at least one sidewalk is provided for pedestrian traffic. Short span slabs are built the full width of the roadbed. In a few cases where the alignment is good on a route whose future traffic possibilities seem light, a long span structure is built with a 20 ft. roadway. I'm sure we are not building too wide; my chief concern is whether we are underestimating the future as Governor Harmon did.

In case of long structures inside municipalities, there is a different problem. Here the roadway is used by traffic moving under control and the width of roadway may well be analyzed in terms of traffic lanes of standard width. It should be borne in mind that such a viaduct or bridge will take care of much more traffic than an approach street of the same width, since it is free from the obstruction of parked machines, and the congestion due to cross traffic.

The specifications for loads have been undergoing some changes. The usual load units, the 15 and 20 ton trucks, are specified for floor loads but by actual test it has been determined that as much as 80 percent of the load of a truck may be borne by one axle. This condition has increased our assumptions for load concentrations. Furthermore, recent specifications require cross floor beams to be designed to sustain as many of these heavy axle loads as the width of roadway will accommodate. These two provisions call for considerably heavier floors than we had previously provided.

The American Association of State Highway Officials with the cooperation of the U. S. Bureau of Public Roads are to be commended for their efforts to standardize Specifications for Highway Structures. Most State Highway Departments have found it necessary to standardize their structural designs as much as possible, and it entails arduous labor and great expense to revise these frequently, to meet ever changing specifications. Of course, it is unthinkable that specifications should be closed to revision, but if our roadways and loads are ample for future requirements, other improvements can be made progressively without serious inconvenience or loss.

At present, we in Ohio are confronted with the task of preparing about 150 Standard Structural Drawings to conform to present specifications. Our concrete designs will consist mostly of the usual types, namely; slab bridges, deck beams and girders, through girders, open and filled spandrel arches, bowstring arches, through arches, standard abutments, railings and miscellaneous items. Our steel structures will have no unusual span lengths, hence there will be no demand for unusual types of trusses. It is quite probable after the design drawings are all worked up, that we will prepare shop drawings for our standard steel structures, to be furnished the fabricator. This will be an innovation in Ohio, but it seems desirable for various reasons. It will eliminate a lot of duplication of effort on the part of fabricators. It would make us responsible for compliance with our specifications and would eliminate the necessity of our spending a lot of time checking and rechecking submitted shop drawings. As a result each job would be speeded up by several weeks. This is not an announced policy but a contemplated one on which discussion is invited.

Perhaps the most pioneering phase of our work will be the use of an unusually rich mix of concrete for superstructures, with unit stresses in concrete increased over those which we have used in the past. Most specifications permit an increase in the allowable unit stresses in concrete if, by increasing the cement content, the ultimate strength of the concrete is correspondingly increased.

We have carefully prepared some comparative designs using a 1 to 5 mix (approximately 1-2 3) allowing a 10 percent increase in unit stresses in concrete over what was permitted formerly for the nominal 1-2-4 mix. This higher unit stress enables the size of members to be reduced which, in turn, lessens the dead load. As a result we find, in the case of a 60 ft. girder with a 24 ft. roadway, for example, that the total cost of the superstructure with the richer mix is 6 percent less than that with the leaner mix. There are other decided advantages; the depth of the floor system is reduced, making available a larger waterway, using the same established grade; the size

of principal members can be held to more pleasing proportions; and the higher mortar content gives greater assurance of perfect embedment of steel, lack of honey comb, and a good surface finish. To offset the tendency of the richer concrete to develop shrinkage cracks, we must take greater pains in the curing of the concrete. This should be done anyway, for I feel sure that our structures have not received as careful attention in this respect as our pavements whereas the reverse should be true.

Perhaps the one type of bridge used in Ohio which is most frequently commented on, is the through concrete arch with the ribs extending above the roadway, in some cases far enough to require the use of overhead bracing. I do not mean to infer that this type of construction is peculiar to Ohio, but we have used it extensively and it is popular. It is economical and is peculiarly fitted to shallow waterways where there is a suitable foundation.

In connection with steel bridges, I am going to make a plea for a seamingly lost cause. I suppose I shall be dubbed old-fashioned—possibly so far behind the procession as not even to be a trailer. Personally, I think we took a step backward when, following the lead of the railroad bridge engineer, we abandoned the pin-connected truss for the full-riveted one. I recall the time when we were afraid to put a concrete floor on a pin-connected truss on account of the vibration. This was about the same time that shops were going largely to riveted trusses at the instance of the railroads who favored and still favor this type of truss on account of its stiffness. Today the pin-connected type is avoided because the manufacture of eye-bars is centered in such few places that there is little competition and this cost is too high. In the face of these circumstances why bring up the pin-connected truss? Because it provides all the stiffness required of a highway bridge in which the dead load is large and live load is small compared with the railroad bridge and it has certain features which argue for a much longer life than the riveted truss. Isn't this what we are paying for when we buy a bridge?

Especially in the case of the bottom chord of a truss where the member is horizontal and below the floor, is there a strong tendency to collect dirt and moisture. This member in a riveted truss of ordinary length is usually composed of angles or channels, possibly combined with plates and tied across with tie plates. All these members are thin, compared to their cross sectional area, thus presenting a large surface area for corrosion and have horizontal elements which tend to hold dirt and moisture and accelerate corrosion. Contrast this with the eyebar which is a compact element presenting small surface area, and, most important, is always placed with the wide dimension vertical, while the heads by their shape naturally clean themselves with every rain. Based upon observation of many bridges my judgment is that the eye-bar lower chord is much more durable than the one that is built up. I am wondering if any other bridge engineer agrees with me. At present we are using riveted trusses, but I would welcome any concerted move back (?) to the pin-connections for the bottom chord especially.

There are several details of design which I'm sure have been receiving more attention during recent years than they did formerly. Perhaps the foremost of these in concrete work is the expansion joint, and devices designed to give it freedom of action. The ideal joint is a butt joint with an open air space or mastic filler, the joint being sealed against the passage of water. Silding joints with interposed layers of tarred paper in my opinion are non-working joints and almost certain causes of spalling failures. If a bearing surface must permit longitudinal movement of a superstructure it is preferable to use either metal rockers or highly polished phosphor bronze plates to facilitate the movement. We are proposing to take care of this problem on an important structure by the use of flexural columns which eliminate any sliding action.

Another detail of design is the providing of reinforced approach slabs, bridging backfills behind abutments, thus eliminating objectionable settlements. In Ohio this is now the standard practice for bridges on all hard surfaced highways. In some instances we have accomplished this by designing cross beams between the wing walls of a U-abutment, these beams supporting the approach slab and restraining the wings at the top. This withstands some earth pressure against the wings and can be taken into account in their design. Since the slab serves as a pavement, its use does not add materially to the cost.

The question of curbs and guard-rails on bridges is receiving far more attention than it formerly did. The height of

curb instead of being insignificant, may, in cases where sidewalks are used, mean the difference between safety and disaster to both motorist and pedestrian. In cold climates where gutters get clogged with ice and snow, I believe that 1 ft. is not too high for a curb which separates the roadway from a sidewalk on a bridge. In the past year there have been two instances that I know of, in Ohio, where the normal curb failed to prevent a machine from going over the sidewalk and breaking through the railing.

I have felt for some time that the typical latticed guardrail used on steel structures is a relic of the days when its chief purpose was to prevent Dobbin from doing something rash in a moment of excitement. So far as its being a protection to either motor vehicle or structure under present traffic conditions it is certainly a failure. In fact it invites them to lock horns. We have recently designed a new type of guard-rail which we are now using on all our new steel structures and also for renewal on old structures when practicable. The aim of the design is to get a rail that is sturdy where needed and presents a smooth surface to a hub or bumper of an automobile. The main guard consists of a heavy weight 8 in. channel to each flange of which is riveted an angle, the arrangement avoiding the projection of rivet heads on the face of the guard. Above this built up member is an extra strong 2½ in. pipe supported at intervals, to serve as a rail for pedestrians and, perhaps in an emergency, prevent the overturning of a machine. While considerably heavier than the old style latticed rail its cost is very little greater. For the sake of visibility the entire railing is painted white. I believe the railing will be a success but prefer to curb my enthusiasm until the rail has stood the test of service.

As a further service to those who use our highways, we are contemplating making our new concrete railings out of white Portland cement concrete; it will cost from 60 to 75 cts. more per foot of railing than our cost has been, using ordinary cement. I understand California has been doing this for some time and that it is popular there.

In the case of through girders and through arches where these members serve as a railing it will not be so easy to adopt the white cement, but I believe we may work out a method in which an end post is used and poured with white cement at the same time the rest of the structure is poured.

As to construction developments, there are not many feaures wherein the bridge industry has outstripped highway work in general. In fact, I believe we are behind the road men in many respects. For example, in Ohio it is much easier for us to get contractors who use the most modern equipment and methods on a ten mile road contract than it is to get them interested in an isolated small bridge job.

A difficulty which we have not been able to solve to our satisfaction arises in connection with cylinder tests where the samples are taken from concrete in the course of a day's run during which perhaps the entire superstructure of a bridge is poured. Our specifications state a minimum cylinder strength. Sometimes a structure is built under inspection, from materials that have been pronounced as meeting the specifications, and no one knows of any shortcomings until perhaps 7 or 28 days after the work is done, when word comes that the cylinders failed to meet the specifications. In such cases what is the proper course for an engineer to take if he desires to be fair with the contractor? It may be that the failure of the cylinder was due to improper handling, or curing, or that the season of the year prevented normal strength development. This is perhaps a testing engineer's problem, but it is so closely related to construction that I would like to hear it discussed.

Generally, I believe there is getting to be a better working relationship between the contractor and the engineer on bridge work. The contractor has gradually conceded the right to the engineer to tell him where to start and stop his day's work when he has learned the importance of the location of these construction joints.

Viewing the behavior of expansion joints, I doubt if either our contractors or inspectors realize the really painstaking skill that is required in their construction. Of course, there are some notable exceptions.

In the matter of mixing concrete there is no doubt but that we are getting a product with improved strength. However, it is my opinion that we will not get the uniformity that we hope for until some system such as the inundation or weight method is adopted that will eliminate the variation in the amount of

water used, and the inconsistency in volume of fine aggregate.

In the matter of surface finish of our concrete, I'm sure there is a decided improvement. When once we have convinced our contractors that the right time to surface finish their structural concrete, is also the cheapest time for them to do it, we shall be on a smoother road to smoother concrete.

Perhaps the strongest appeal which modern highway bridge engineering has for the layman comes from those bold spectacular structures which have made some of our most scenic routes possible. It is only in rugged country that such opportunities present themselves. However, the attention of the specialist, the touch of a trained hand in the fitting of a bridge to the needs of the road is apparent on many of our highways.

I'm sure that every bridge engineer here can cite instances where he has designed a bridge conforming to horizontal and vertical curves, superelevated to fit the former, the whole structure perhaps accommodating a skewed watercourse. When we compare a well-built structure of that sort with some of the ill adapted structures of an earlier day, we must admit that highway bridge engineers are doing their part in the development of our highways.

MICHIGAN GOVERNOR PROMISES ROAD STATEMENT

(The following article is reprinted from "Michigan Roads and Pavements" of April 15, 1926. It was written by J. W. Hannen, editor of the magazine.)

The expected clash between Governor Alex J. Groesbeck and the members of the road committee, Secretary of State Chas J. DeLand, Superintendent of Public Instruction Thos. E. Johnson and State Treasurer Frank D. McKay, materialized at the meeting, on April 14, in the office of the Governor in the state capitol at Lansing.

In their demands upon the State Highway Department and State Budget Director Henry Croll, Jr., while the Governor was out of the state, the members of the road committee made the assertion that they wished to determine exactly what the highway department's available resources were before recommending or voting for any further awards of contracts. Tentative figures had been compiled by which the members of the committee concluded that the 1926 resources of the State Highway Department were so encumbered as to prohibit road construction not already started during the current season. Subsequent statements issued by the Governor and State Budget Director Croll have been declared by members of the committee as incomplete and not a correct analysis of the financial condition of the State Highway Department.

Governor Shows Excess of $3,667,407

On April 13 Governor Groesbeck submitted a statement in which a surplus was shown, and that the excess of assets over liabilities as of July 1, 1926, would be $3,667,407.53. The officials who demanded a detailed statement declared that this statement was incomplete and misleading, and this was the basis of a heated session on April 13, the committee declaring that instead of there being an excess over liabilities at the end of the fiscal year, June 30, 1926, there appeared a deficit. Secretary of State DeLand reiterated his demand for a detailed statement, this demand being supported by Superintendent of Public Instruction Johnson and State Treasurer McKay. The clash was precipitated when State Highway Commissioner Frank F. Rogers recommended the award of 7.147 miles of Class A 18 foot gravel on Trunk Line 14, Cheboygan county, a Federal Aid project, to Fred McNally of Bridgeport, Michigan, at $55,519.14.

In submitting his recommendation Commissioner Rogers supplemented his remarks upon the subject by stating that if he did not think the funds were available for the completion of the project he would not have made the recommendation.

Mr. Johnson moved to refer the matter to the road committee. Mr. Rogers offered an amendment that the contract be awarded.

When Governor Groesbeck, as chairman of the board, put the motion made by Commissioner Rogers, Auditor General Fuller, before voting, stated that he wished to be informed as to whether it was definitely known that the funds for the project were available, further stating that he had not been able to determine that there were any funds available for further highway construction.

The vote upon the motion was incompleted as at this point a spirited discussion was entered into by the Governor and members of the board upon the financial condition of the State Highway Department. The outcome of this was a demand by Governor Groesbeck of Mr. Fuller and the other members of the

board as to exactly what they desired in the matter of a financial statement, and after considerable discussion upon the question the Governor emphatically stated that the information sought would be given, and the board adjourned subject to the call of the Governor, when the report in question shall have been completed.

No Action on Low Bids Submitted

While the action of the board hinged upon the awarding of the contract for the Cheboygan county project, there were several other projects in the report of low bids, all in Sanilac county, which did not come up for discussion, and these, together with the Cheboygan county project, have been side-tracked until the board gives further consideration to the financial resources of the Highway Department.

In submitting his recommendation Commissioner Rogers stated that 15 percent of the amount of the contract had been provided by Cheboygan county, 50 percent by the Federal Government, the remainder of the cost to be borne by the state.

Governor Groesbeck opposed reference of the matter to the road committee. He said:

"These projects were passed upon by the State Administrative Board nearly a year ago, when the matter of relocation was submitted and discussed in connection with the requirements of the government in the matter of Federal aid. Since that time the relocation obstacle has been disposed of. There is no necessity to refer the matter to any committee.

The Governor asked the stenographer to produce the minutes of the meeting of the board at which this matter was first brought up. The minutes showed that the project was before the board on May 13, 1925, together with several other projects. The record showed that a motion was at that time made, and carried to prepare the plans and to advertise for bids.

Secretary of State DeLand resented statements that had gone about the state that the road committee was responsible for the awarding of road contracts and he desired to have such impression corrected. He asserted that all projects were not reported upon by the committee, only those about which there was a controversy, or details to be worked out.

Governor Groesbeck asserted that all contracts were authorized by the board and passed upon by the members before action was taken.

"All this controversy is 'much ado about nothing' and conversations relative to the state's business have nothing to do with the action of the board. Every member of the board acted upon these projects and the facts in relation to them were before all of the members. For that reason I can see no excuse for further reference of this project to the road committee," asserted the Governor.

"Then you had better abolish the road committee," declared Mr. DeLand.

Continuing the discussion, Governor Groesbeck stated: "The State Administrative Board has done a splendid job for the state and the State Highway Department has performed a splendid service, and some of the things charged against the Highway Department must be taken back."

In further discussion of the subject, the Governor declared that in his opinion the contract should be awarded. Then followed more spirited debate upon the general highway situation, until finally the Governor demanded of his critics on the board:

"Now, tell me just what do you want in the matter of information?" The Governor directed this question to Auditor General Fuller. Mr. Fuller stated that it was apparent that there were no funds for further road construction and that he opposed awarding more contracts until it was definitely known that resources were available. He said that he did not expect all the little details as to mileage, names of contractors, etc., but a comprehensive statement of available resources and obligations.

This same question was put to Mr. Deland and Mr. McKay. Mr. McKay emphasized his desire that among other things already discussed there should be a complete statement as to amounts of monies paid in by counties on account of road projects and bridges. Mr. Rogers said that could easily be given. Mr. DeLand went further and declared that he desired a complete statement of all contracts completed in 1925, all projects held over, amount of money paid on each, and amount of money to become due when contracts are completed.

Governor Declares Figures Correct

"I have submitted statements relative to the financial condition of the State Highway Department, which are correct. As to the specific details discussed these cannot be given in a short time, but the available totals have been known, and it has been known also that it would be easy to meet the cost of contemplated

road construction," declared the Governor. "All of these figures are available to anyone. I will not argue the matter of the calendar year and fiscal year involved in the state's finances, but I wish to state that the road work carried over from 1925, by which a portion of the 1926 resources is encumbered, is less than previous years. I will not argue the intricate details, as I am interested in the business of building the state's highways."

Commissioner Rogers explained the difficulty in making a detailed report quickly and stated that while the Highway Department had a record of all contracts, including amounts and specifications, there were other details included in the cost of highway or bridge construction that went through the Administrative Board's accounting division, which he was engaged in securing. He stated that his office was now compiling the biennial report of the department, which would show exactly all of the details demanded by its critics.

Nothing Due on Maintenance

There was some discussion upon the item of $2,800,000 shown in the report as "balance owing on maintenance."

Commissioner Rogers stated that there was nothing owing on maintenance, but that this item contemplated the total requirements up to the close of the present calendar year and that all maintenance bills were paid monthly.

Included in the discussion was the matter of road construction carried on by the state. In this connection Governor Groesbeck stated that there were about 60 miles and that he could give specific details on that point. This brought up the subject of "Wider Woodward Avenue" and the amount of money involved in securing the rights of way. Governor Groesbeck explained that the state could show a salvage item of $850,000 in this connection. Mr. DeLand declared that it was not a quick asset and should not have been submitted in the report as such. Governor Groesbeck retorted that it was necessary to include that item among the states' assets as it was an asset that could be realized upon in full without any question. He said: "While under present conditions this amount is not immediately available, it can be converted into a quick asset at any time, for the full amount, but that is not at all necessary."

Mr. DeLand came back with the assertion that it would not be available this year. To this the Governor replied, "It will not be needed."

Mr. Johnson requested that a complete statement of the rights of way upon Wider Woodward Avenue, Telegraph road, and other projects, be submitted.

This practically completed the discussion and in conclusion the Governor said: "Now, if that is all the information you wanted we will adjourn, subject to call."

Mr. DeLand declared: "We want a complete statement of assets and liabilities."

Governor Groesbeck replied: "Now that I know what you want I will find out just how hard it is to get that information."

SEWAGE PLANT OPERATION IN IOWA

By Hans V. Pedersen, Civil and Sanitary Engineer, Iowa State Department of Health, Des Moines, Iowa.

(Paper read at 7th Conference on Sewage Treatment at Ames, Iowa, November, 1925.)

The State Department of Health of Iowa has just completed a survey of all the cities and towns in the 26 counties that constitute the major portion of the Iowa and Cedar river valleys. Out of the 222 municipalities located in this area, 81 have sanitary sewer systems. Of those having sanitary sewer systems, 24 dispose of their sewage by dilution, that is, by discharging it directly into a stream of water. The rest of these municipalities (a total of 57) purify their sewage to some degree by means of some type of sewage treatment before discharging it into near-by water sources.

Condition of Sewage-Treatment Plants

It is interesting to note that out of the 57 sewage-treatment plants investigated, 31 were reported as being in very bad shape due to a lack of proper attention. There were very few reported as working at maximum efficiency. Most of the sewage-tank trouble was laid to the presence of too much sludge in the digestion chamber. Some of the troubles reported in connection with the sand beds were growths of weeds, deep plowing with horse power, replacement of filter sand with a dirty non-uniform pit-run sand, overloading as a result of high rate of infiltration into the sewers, and failure to repair the distribution system. Some of the filter beds were by-passed entirely, because the siphons were out of order.

Causes of Poor Plant Operation

There are two reasons why there are so many poorly-operated municipal sewage-treatment plants in Iowa. The first reason is that the average city or town council fails to realize the necessity of providing a competent, intelligent, and industrious plant operator to perform certain fundamental duties at the right time and in the right way; and the second reason is that the average council fails to provide yearly a sufficient repair and replacement fund.

Theoretically, the town council or governing group should be elected to office to look after the welfare of the community, and to act as guardians of the public health. It should provide a safe and palatable public water-supply, as well as install and maintain adequate methods of collecting and disposing of sewage, garbage, and filth. In other words, a governing council should keep the community clean and sanitary and promote such conditions as will make that community a healthful place in which to live.

Oftentimes, however, the purposes for which city and town councils should be elected seem to have been lost sight of. The majority of voters go to the polls today with just one purpose in mind, and that is to elect councilmen who will reduce the city's expense and thereby reduse the personal taxes of the voters. An individual looks at the record of the last council. He remembers how he voted for men who had promised to lower taxes. But what did they do? Nothing. The average voter in the smaller community reasons that, because of the failure on the part of the last council to reduce taxes, he must have been mistaken in his judgment of men; and so he goes to the polls the next time and casts his vote for an entirely new group, hoping and trusting that he has at last elected a group of honest men of such marvelous ability as to be able to run the city's business better than ever before without spending nearly as much.

And so it is that every city election brings forth new councilmen, and the new inexperienced council is forced to begin work, not where the old council left off, but practically where the old council started.

Economy Often Costly

It is natural to expect that a council elected under such conditions would seek every opportunity to save money. Unnecessary expenditure of money should be as foreign in cities as an Eskimo is in Florida, but oftentimes a new council in its effort to reduce taxes fails to distinguish between necessary and unnecessary expenditures. The majority of such mistakes are generally rectified with little or no damage, but sometimes a council wakes up too late and finds that because it failed to spend a small sum of money at the right time, it is forced to spend a much larger sum or to take the chance of losing an entire investment.

Care and Maintenance Necessary

New councils as a rule under-estimate the necessity of providing a definite sum of money to keep the municipal sewage-treatment plant in repair and to pay for the necessary care. In the first place, sewage-treatment plants are not very well understood. Many people have the idea that such plants are supposed to be automatic, or that they will take care of themselves if let alone. Some people regard them as institutions of mystery—things that should not be interfered with for fear of unknown consequences. A reason once given for permitting a plant to take care of itself too long was that no one on the council knew what to do so they did nothing for fear they might spoil something. Lack of information or the failure to provide a competent caretaker has ruined many a good sewage-treatment plant in Iowa.

A Business Problem

But what is to be done about correcting such a state of affairs? Is it expedient or good business on the part of the people of the state to sit idly by and let a perfectly good sewage-treatment plant that cost the various communities from twenty-five thousand to two hundred thousand dollars become inoperative or entirely out of commission in a short period of time? A well-designed sewage-treatment plant adequate for a small community, if properly cared for, should last a lifetime with very little expense outside of the salary of the operator. Which is really better, then, to provide a competent caretaker from year to year, or to dispense with the caretaker and practically rebuild the plant at the end of ten years?

Three Suggestions

With a view to the prevention in the future of unnecessary expenditures of money due to such ignorance and misunderstandings as to the needs of municipal sewage-treatment plants, the following suggestions are offered:

(1) Licensed Operators

It is proposed that a state law be passed requiring every city or town hav-

ing a municipal sewage-treatment plant to employ a licensed operator to look after the plant. Such a license should be granted by the State Department of Health after the applicant is thoroughly informed as to his several duties; it should be granted either upon a written or an oral examination. A suggested qualification for the right to take such an examination is that the applicant must attend two conferences of sewage-treatment plant operators as held under the auspices of the Engineering Extension Department of the Iowa State College at Ames.

A licensed operator is suggested for the reason that this will prevent new councils from removing a competent operator for political reasons and placing a man in charge who does not understand the working of a treatment plant. There will undoubtedly be objections to the licensing of such operators, due to petty reasons and fears, chief among which would probably be the fear that this licensing would tend to increase the salaries of operators. In spite of all objections, however, if it is necessary to install sewage-treatment plants in the first place, it is certainly necessary that they function properly; and the best way to assure good operation is to provide competent men to look after them. The most effective way to assure competent operators is to require that they be licensed.

(2) Weekly Reports

It is proposed that each operator be required to fill in a weekly report card as furnished by the State Department of Health, giving a record of just what work has been performed on the plant during that week.

The weekly report card will indicate to port card could not take the place of a large extent whether the operator is really competent and is really performing his duties in a systematic way. The re- the licence. In fact, it is doubtful whether the filling out of report cards could be enforced unless the penalty of losing one's license for failure to do so could be provided.

(3) Inspection Engineer

It is proposed that a full-time sanitary engineer be added to the Sanitary Engineering Division of the State Department of Health, whose duty it will be to visit each municipal sewage-treatment plant in the state periodically for the purpose of investigating the plant and advising both the council and the operator concerning things that should be done to improve the operation.

The addition of a full-time sanitary engineer to the Engineering Division is suggested for the reason that there is nothing like personal instruction. An operator might be licensed and he might fill out a report card in an intelligent way, but still he may know very little about the fine points of sewage treatment. Knowing that the better a man really understands his work the better his results will be, it is suggested that a department engineer visit each plant at least once each week in order to point out the weak spots and to take each operator into his confidence.

Summary

There are at the present time approximately two hundred municipal sewage-treatment plants in Iowa. Judging from the results of the recent survey of 26 counties, it is safe to say that one-half of these plants are laboring under difficulties brought about by incompetent operation. There is a movement throughout the state to compel cities now discharging sewage into rivers to install sewage-treatment plants. It is indeed important to install treatment plants where they are really necessary, but it is just as important to operate properly the ones that have already been installed.

If the people of Iowa are really taking seriously the question of preventing stream pollution, they must see that the sewage-treatment plants installed for this purpose actually produce the results for which they were built. If the people of the state are really taking seriously the mattery of city expense, they must know that it is not true economy to pare down the cost of operating a plant for a period of years, and then spend many times more at the end of that period. Satisfactory results can never be obtained from sewage-treatment plants without proper operation, and proper operation in the majority of places will never be obtained until the councils are made to realize, through education and legislation, that they must provide competent operators and provide sufficient money for yearly repairs.

COMPENSATION OF ENGINEERS

(Editor's Note: The following article is an address by Charles S. Shaughnessy before the Philadelphia Chapter of the American Association of Engineers on Dec. 9, 1925.)

The year 1914 marked the beginning of

collective activity for the improvement in status of the engineering profession. It was also the beginning of a period which has not yet ended of an extraordinary inflation of prices in living commodities so that the present year, namely, 1925, shows an advance of 75 percent in the cost of living beyond that of 1914. If engineers' salaries had been reasonable and adequate in the latter year there should have been an increase of 75 percent to be even parallel or commensurate with conditions before the war.

Discrimination Against Engineers

In order to show how the engineers have been discriminated against during this period of advancing prices, I refer to a study made by William C. Beyer of the Philadelphia Bureau of Municipal Research, showing the salaries of municipal employees in the twelve largest cities of the United States. The average increase for all the employees in these cities is about 61 per cent or 14 percent below the increase in the cost of living; for patrolmen and hosemen the increase has been 71 percent; for unskilled labor 97 per cent; for teachers in the public schools 83 percent to 141 percent. All of these groups fared reasonably well largely through organization effort. Looking now to the case of the engineers, we find that this increase was 41 percent, the lowest figure of any class in these municipalities and it should be observed that the engineers constitute the largest professional group in our municipal services.

While the engineers made no vigorous protest until 1925, there were occasional and outstanding complaints from the year 1914. During 1925, the pressure upon financial bodies gained considerable momentum and we found it breaking out among the county engineers in Ohio, the state employees of Massachusetts, the city employees of Chicago and New York and in other jurisdictions scattered throughout the country.

New York and Chicago

These two cities marshalled the most convincing array of facts as to comparative salaries of engineers and other groups that have been compiled and they are worthy of mention here. The Engineering Employees Association of the City of Chicago in January, 1925, appealed to the mayor and to the city council for an adjustment of salaries to meet the present price levels, basing their request on the following facts:

1. That the engineer's salary is not adequate when referred to the scale of 1913 corrected by the present price index of living commodities and that the salary is not adequate to provide a living commensurate with such activities as are inseparably a part of the existence and scientific growth of the engineer.

2. That the engineer with his scientific training renders the city services that are indispensable and that the present and the future physical welfare of the municipality are dependent upon and reflect the quality of such engineering service.

In addition to this protest, the engineers suspended work for a day or two in order to bring the matter to the attention of the public and city officials.

The supporting data showing the comparative study of living costs and increase in salaries since 1913 show a range in percentage increase in salary from zero for the higher grades to 78 percent for the lower grades. In other words, the engineers performing work of the greatest responsibility were given no increase while those in the lower grades were advanced in the same ratio as the cost of living. A study of the salaries in other cities showed that Chicago, Cincinnati and Indianapolis were comparatively worse off than New York, Detroit or Cleveland.

The Chicago report quoted an editorial from the Saturday Evening Post for July 5, 1924, which pictures the situation most strikingly. It says:

"Engineers, technologists and men of science, taken as a single group, must now be at the top or very near the top of the list of the conspicuously underpaid. We exempt from this classification those engaged in selling and those who occupy high executive positions. We include in it those whose work is strictly professional.

Such training represents large investment of money, time, brain power and moral stamina. Higher technical courses cost much to give and much to receive. They require, among other things, laboratories equipped with heavy machinery, instruments of precision and costly accessories of a hundred sorts. Instructors must be men of unusual equipment who know how to teach as well as how to practice. Mathematics is the mainstay of many of these courses, for today the small task of science is conducted in the vernacular of calculus. The training is severe because it consists largely in the inculcation of principles, and principles

are always more difficult to grasp than facts or mere information. The resulting equipment is of the most substantial sort, for if it has any merit at all it has the faculty of enabling men not only to handle routine work with efficiency but to attack new and strange problems in the orderly and well reasoned fashion that leads to final success. He who can blaze new trails and establish new outposts in the domain of science or industrial technology is too valuable a citizen to grind down.

"Men of this stamp are notoriously underpaid. Bureau scientists in Washington, conspicuous examples of the faithful public servant, work for salaries that a self-respecting plasterer would call cigarette money. Research men in the laboratories of great corporations fare better, but by no means well. Engineering experts in a dozen fields, well equipped specialists, are often so ill rewarded that they find it hard to live in modest comfort.

"These conditions are beginning to produce the inevitable result. Educators who are trying to assist young men in their selection of a career are telling the truth about the engineering professions and are comparing them unfavorably with other fields of activity. Engineers themselves are equally frank when advising their young friends. Clear-thinking, well-trained young men are too precious an asset to put into blind alley jobs.

"Scouts from the great industrial corporations each spring look over the graduating classes of our technical schools with a view to engaging promising students. Of late they have been complaining of the insufficiency of the material at their disposal. In some instances they have been frankly told that they want too much for what they are willing to pay and that they cannot hope to find their needs fully supplied until they are prepared to pay a fair price for the costly and hard-won mental equipment whose benefits they desire.

From colonial times our people have had a genius for mechanics, invention and applied science. It would be a national calamity if we should be so short-sighted as to starve out this priceless talent. If there is any one thing about our social evolution that is certain, it is our growing dependence upon science to solve the problems of peace and war and everyday life. To weaken by neglect or indifference those powers upon which our future existence may depend would be sheer folly."

The Situation in New York

The Association of Engineers of New York petitioned the Board of Estimate and Apportionment last August for increased compensation and brought out some striking contrasts between the engineers' salaries and those attached to other lines of work. In 1914 the engineers' salaries averaged $1,837, and these were advanced in small increments until in August, 1925, the average was $2,647 or 44 percent advance. During this time teachers were increased 88 percent, foremen mechanics 108 percent, mechanics 110 percent and unskilled labor 140 percent. The legal profession in 1914 averaged about three times that of the engineering profession, or $5,400 a year. This association made a modest request for a flat increase of 25 percent and while this would not bring the salaries parallel with other professions or trades, it would restore the engineering profession to the approximate levels that prevailed in 1914. The Engineering News Record in commenting editorially upon this request said: "The city engineer has taken his lot supinely and his wage position shows fession of engineering. In my peregrit. Now that he is beginning to assert himself, possibly he will begin to get results worth while."

The Situation in Ohio

In the state of Ohio a campaign was begun last March to secure increased compensation for the county surveyors. Arthur Richards, city engineer of Chillicothe, O., says in the Professional Engineer:

"Oppression always has been a deterrent to progress, both materially and intellectually, and I am of the opinion that financial oppression in a modified form has had a serious effect on the intellectual advancement of a great group of engineers who occupy positions of only average importance—because of the apathy in the past among the lower group of engineers and total indifference by the upper group no definite program has been devised looking toward the general elevation of the lower group through the cooperation and efforts of the upper one. Great harm has been done by the supervisory engineers in refusing to grant proper and just remuneration to those working under them. As an example some of the profession protested a per diem rate for the State Board of Regis-

tration claiming that such work should be done gratuitously."

Mr. Richards brought out the fact that 59 percent of the county surveyors of Ohio received less than $3,000 a year and each of them is responsible for about $250,000 worth of work annually. Mr. Richards' comment on the lack of support given by supervisory engineers to those under them coincides in a measure with the conclusion of the committee of the American Society of Civil Engineers which investigated the conditions of employment and compensation in 1914. The final report states:

"The underpaid engineer does not always owe his failure to receive a salary commensurate with the importance or difficulty of his work to the ignorance or lack of appreciation of laymen, but it not infrequently is the fault of his engineering superior in the organization of which he is a part. The replies received by the committee indicate that engineers in private practice sometimes employ men of extensive experience, and presumably of good ability, at salaries which young graduates with little or no experience are able to command, but which are less than those of an ordinary mechanic who has a labor organization behind him. It may be urged that the competition for work on the part of engineers who employ a technical staff is so keen that it is necessary to take advantage of the needs of those seeking employment in order to secure professional work which is frequently let to the lowest bidder. Engineers in private practice are often criticized because they have not established a scale of charges on a percentage basis as have the architects, but in the offices of leading architects will be found young men who are willing to work for almost nothing for the sake of the experience they hope to gain. The fact remains that employing engineers are sometimes disposed to pay their men less than their services are actually worth. The Code of Ethics, adopted by the Society by letter-ballot on Sept. 2, 1914, lays special emphasis upon the relation of the engineer to his client and to that of competing engineers, who may be striving to secure the same contract or commission, toward each other, but it makes no mention of the obligations of the engineer as an employer to men of his own profession. It appears to lose sight of the need of guarding against underpaying as well as against underbidding."

The Outlook for Civil Engineers

It seems to me that the movement for increased price levels for engineering service is gaining momentum. The large corporations, railroads and public bodies are having this fact pressed upon them by our organizations and by the press of the country. There are also unmistakable signs of a changed public attitude toward the engineering profession and this always is a forerunner of an improvemnt in compensation and a more equitable standard as compared with other lines of work. Professor George F. Swain has brought this fact out in his book on "The Young Man and Civil Engineering." In speaking of the outlook for the civil engineers, he says:

"When it is recognized how wide the field of civil engineering is, how many necessary and constantly expanding fields of human industry it touches, it becomes evident that notwithstanding necessary variations in business activity, the outlook for the civil engineer must be good, and the demand for his services constantly—though not uniformly—increasing. It cannot be otherwise unless the progress of industry is to permanently retrogress. The appreciation of his services, and the compensation paid him, must also increase. There has been a noticeable improvement in this respect in the last few decades. There will, of course, be periods of business depression, when numbers of engineers, as of other men, will be out of employment, but the general trend will be upward. This is particularly so in view of the opportunities that an engineering training offers of engaging in business, in administrative and other positions where engineering knowledge is necessary or desirable, and in view of the fact that the habits of prompt decision, initiative, resource, and ability to meet new conditions—all of which habits should be developed by an engineering education and by engineering experience—are potent elements in success."

THE ENGINEER

By E. W. Beatty, President, Canadian Pacific Railway

(From an address delivered on March 10, 1926, before the American Railway Engineering Association.)

It is a very great pleasure and honor for me to attend this dinner of the members of the American Railway Engineers Association, and it is particularly so be-

cause one of our own officers is your president. As a Canadian and as a fellow officer of the Canadian Pacific Railway Company, I congratulate him on the distinction you have conferred upon him. As a boy I had a great ambition to be an engineer. My mother wanted me to be a minister and my father, a doctor, so naturally I became a lawyer. The kind of engineer I wanted to become was not that associated with most boys' ambitions—the driver of an engine—but a man who constructed things.

Engineers' Achievements as Monuments

No profession of which I am aware has that opportunity of leaving behind it physical achievements as does the pronations around the country, which are somewhat extensive, I never see a bridge or a tunnel of conspicuous proportions or difficulty in construction, or a viaduct, that I do not feel than any man should be proud that he created, erected or constructed such a work and left behind him one or many, as the case may be, concrete evidences of his own achievement.

This is not to be wondered at when you consider that no matter how able he may be, few men are permitted to leave behind them evidences of their own work which may be pointed to by future generations as a great conception or a great execution.

My appreciation of engineers is not confined to the negative recognition they receive as gentlemen well versed in the science of underestimating and overexpending which seems to be part of my daily diet with them, but because of the fact that the inspiration to become an engineer involves certain characteristics which we all admire. Any man who voluntarily takes up engineering because it appeals to him is rarely anything else but a strong, virile member of the male sex who is not afraid to match his strength and ability against the forces of nature and implicitly believes in his power to overcome them.

Contributions of Engineering

If a properly conceived Encyclopedia were to be compiled of the Dominion of Canada and the United States, my own thought is that one of the most important articles would be devoted to the immense conrtibutions made by engineering to the development of our countries. Without the engineer, we should still be in the wilderness stage, whereas the vast territory from the Atlantic to the Pacific is netted with road, railways, canals and telegraph wires; we have safe and well equipped harbors linked with Europe, the Orient and Australasia by large fleets of ocean-going steamers; our mineral and forest resources are being successfully exploited; our farms are operated with the most up-to-date machinery; our cities are built, paved, drained and lit with electricity as modern cities should be, and we have industrial centers humming with factories of every conceivable kind. In fact, within the last half century, the North American continent has grown to be as much an industrial and commercial as an agricultural country, and for this the engineer is largely responsible.

The astonishing thing is that this transformation has been directed by so few men. In a report which I read recently, the report of an address delivered by Professor C. R. Young to the Toronto branch of the Engineering Institute of Canada, I noticed the statement that there were just 12,000 men holding engineering positions in Canada, and the fear was expressed that the univerisities are turning out too many qualified engineers for the country to absorb. To my mind the answer should be that if so small a body of men has achieved and is continuing to produce so vast a transformation, the greater should be our endeavor to find employment and opportunity for all the men of that type that the universities can turn out.

The Value of the Technically Trained

My own personal training was initially a legal training, and I might be considered as prejudiced in favor of lawyers, but I cannot conceive that Canada would be as pleasant a place to live in as it is if its development should have been left to the tender mercies of 12,000 lawyers. The inference we should draw is that the more engineers we can keep employed, the better for the material progress of the country. It is, however, not altogether correct to credit the whole of this progress and development to the professional engineer. These professional men have been in many instances rather the instruments than the inspirers of the development. But even among the other classes of the community which have actively contributed to this development you find the technically trained men in the forefront. In all our industries and in a great many of our commercial enterprises it is the technically trained man who is pushing to the front. A man who has been through an engineering course understands the machinery of his busi-

ness, is practical and can adapt himself to ever changing conditions.

If I were to be asked what is the most characteristic quality of the Canadian and American of today, I should answer that he is practical. I think this characteristic should be taken into consideration by our educators, who are always preaching to us that the best education is that which develops a natural bent. To my mind there could be no better training for a practically inclined youth, whatever his ultimate calling may be than a course in engineering. He need not take that course with a view to becoming a professional engineer. But he will find that course of substantial value in nearly every kind of business—even a lawyer would be none the worse for it—particularly when that business is concerned with manufacturing or the operating side of any industry. And our employers would be wise to remember that the technically trained man is the most practical and adaptable kind of employee or officer he can get.

I am often asked why we do not find men with engineering training occupying positions in transportation and other similar corporations. Now, as you know, this bald statement is not accurate; in a great many railway companies men of your profession are found in great numbers, not only in the engineering departments but transportation departments, but it is also true that in other companies, and I think this applies to practically all Canadian companies, engineers except those carrying on their profession within the ranks of the corporation, are a very small percentage of the companies' officers.

One would naturally think that a young man, well educated, of good physique and trained in engineering, would be attracted to railway work and the only explanation I can make is one which applies to all college men in large businesses. Universities can give a man much. They can give him the rudiments of knowledge, they can teach him to think logically and correctly, they can teach him to study but they cannot make him anything. That is a responsibility he must assume and a result which he can only accomplish himself.

Now, one of the difficulties confronting large corporations—and you can take it as admitted that all corporations now admit the value of educated men in their service—is the acknowledged attitude of the college graduate towards work. By reason of his advantages in education, the young man leaving college is apt to think he is equipped to be an officer or for some superior position without going through the arduous work of apprenticeship. No impression could be more erroneous. The most intelligent college graduate begins his practical work at a disadvantage compared to a man of the same age who has had, let us say, five or six years practical experience. The virtue in education is that it enables a man to overcome that disability, and ten years later the advantage is all with him. A college graduate who is prepared to start at the bottom instead of in the middle or at the top will make rapid progress in transportation service but he must start at the bottom and he must have the mental attitude that puts work—hard and intelligent work—before every consideration.

With these principles admitted, the members of the engineering profession are the most likely recruits to transportation service and become very valuable officers. Of course, to me railroading has always been a very fascinating game. It has its disadvantages. It is exciting. The remuneration a man may obtain is certainly no more and often much less than he can secure in other walks of life, but then all salaried men labor under that disability. He has this assurance, however, that if his office is important enough his salary is at least commensurate with it, and he will soon appreciate that a benevolent government will see that he is not permitted to retain more than a part of it for his own purposes.

PORTLAND CEMENT ASSOCIATION MOVES TO ITS NEW HOME

The general offices of the Portland Cement Association, which for the past ten years have been in the Conway building, 111 West Washington Street, Chicago, have been moved to the Association's new building, Grand Avenue and Dearborn Street, otherwise known as 33 West Grand Avenue. The entire building is occupied by the Portland Cement Association and its research laboratory. For the past ten years the laboratory has been located in the Lewis Institute, Madison and Robey Streets, and heretofore conducted co-operatively by the Institute and the Association.

The architects, Holabird & Roche, have produced a handsome five-story and two-

basement building, resting on thirty concrete caissons carried down to firm bearing. This structure is regarded by engineers, architects and builders as representing the highest type of fire resistive construction and also as a worthy addition to the rapidly growing list of structures which typify the architectural possibilities of concrete.

The Turner Construction Co. of Chicago and New York, which was awarded the contract for this building, began excavation in August. The greater portion of the work was carried on during cold weather. The usual precautions of heating aggregates and protecting concrete from freezing were followed. Floor by floor, the building was enclosed with tarpaulins and heated with salamanders. As a matter of fact, winter temperatures were in no sense a handicap to the orderly and scheduled progress of the work.

Foundation design provides for adding stories to the building if enlargement of Association activties demand more space.

The sub-basement contains the heating, mechanical and electrical equipment servicing the building. The heavier laboratory testing machines are installed in the basement proper, which also contains moist rooms and other facilities for storing the thousands of concrete cylinders which month by month and year by year as they are submitted to test, disclose the results of the many carefully planned researches constantly being conducted.

Other laboratory equipment, a laboratory machine shop, shipping and receiving rooms for the building, reception room, information desk and telephone switchboard are on the first floor. The lobby is a revelation to those unfamiliar with the possibilities of precast concrete stone. Lighting in the reception room is from flood lights, mounted on precast concrete standards.

The precast stone stairway leading to the second floor contributes to other architectural attractions of the lobby. On the second floor is the chemical laboratory and the offices of the director of research and his assistants. The general storage facilities for bulletins, records, etc., are also on this floor. In addition there is a small auditorium and stage.

The third floor is devoted to offices of the structural, railways and cement products bureaus and to the association's reference library. The library probably contains the most comprehensive collection of literature devoted to the uses of cement and concrete in existence. It is a public library in charge of trained librarians, whose services are always at the disposal of architects, engineers, contractors, or any others who desire to avail themselves of its many bound volumes and extensive reference files on the uses of cement and concrete.

Stenographic and mailing departments are on the fourth floor.

The offices of the general manager, assistant general manager and several of the general office bureaus such as advertising, publications, general education, highways, accident prevention, auditing, purchasing, are on the fifth floor. There is also a conference room for staff meetings.

The architects cooperating with the association's building committee and its engineers have provided a building which is distinctive not only because it is substantial and firesafe but because it expresses the economies capable with reinforced concrete design, as well as the architectural possibilities of concrete from the standpoint of art in architecture.

NATIONAL PAVING BRICK MANUFACTURERS MEET.

The National Paving Brick Manufacturers' Association celebrated its 20th anniversary at its annual meeting at the Edgewater Beach Hotel in Chicago Thursday and Friday, January 14th and 15th. More than 100 manufacturers, salesmen, field engineers and superintendents were present.

The principal speakers were Thomas H. MacDonald, Chief of the U. S. Bureau of Public Roads, E. F. Kelly, Chief of the Division of Tests of the U. S. Bureau of Public Roads, E. J. Mehren, Vice President of the McGraw-Mill Company and former Editor of Engineering News-Record, and Dr. G. C. Mars, Director of Service of the American Face Brick Association.

"Cussing the Government" was the subject of Mr. MacDonalds' talk. He referred to those Americans who repeatedly criticize the government on the ground that its income and expenditures are needlessly excessive. He pointed out that considerable more than half of the government's annual expenditures were fixed amounts over which no administration had control, that about 51 per cent went for past wars and for the maintenance of our army and navy.

Mr. MacDonald pointed out that in

many sections of the country, the requirement with regard to paving was for the greatest possible mileage for the least possible expenditure; that many such districts were not ready for pavements of the highest quality, but were forced because of financial limitations to select cheaper types.

Mr. Kelley discussed at some length the research activities of the Bureau of Public Roads, and described in detail the Bureau's present research into the wearing qualities and resistance to impact of vitrified brick of less than 3 ins. in depth.

Mr. Mehren urged upon the industry the necessity of greater effort along educational lines and stressed the need of informing the taxpayers of the country concerning the merits of brick paving. He described modern marketing problems and their solution.

This also was the theme of Dr. Mars' talk in which he emphasized the need for wider advertising in the paving brick industry.

The development of paving brick of less than 3 inches in thickness was discussed in all of these group meetings. It was pointed out that brick 2½ ins. in thickness were now being used on streets and highways for light and medium traffic and that pavements of this design as much as 12 years old are still in excellent condition. Where 2½ in. brick will suffice, it is needlessly expensive to lay a thicker brick.

The wide use of vitrified paving brick in gutters and for parking strips on bituminous paved streets was dwelt on. As an example of the spread of this movement it was pointed out that 3,500,000 paving brick have been used for this purpose recently in the one city of Philadelphia alone.

The association went on record as being desirous of rendering every service within its ability to assist engineers and other public officials in obtaining paving brick of the highest quality and in helping to bring about the best possible construction of brick pavements.

ENGINEER EARNS THE GRAPEFRUIT

(From the Journal of the Western Society of Engineers.)

A number of years ago a neighbor of mine who had a grapefruit ranch in the Isle of Pines told me about his troubles with his water supply. They had rain enough but it did not come at just exactly the right time. The natural suggestion was, "Why don't you build a reservoir?" and this suggestion got me into a lot of trouble for my neighbor wanted to know how large a reservoir should be put up, what it should be built of and a lot of other questions, with a result that before I was through with him, I had designed for him a reinforced concrete reservoir complete with foundations and roof. He assured me that he had excellent sand and gravel on the property and his man down there could build anything.

When it was built he brought me a photograph of the structure and it looked very good; the only trouble was it would not hold water and the suggestion nicely stated was that it was all my fault. Anyhow I got into this thing just to be a good neighbor and although I had spent a good deal of time in figuring the concrete reinforcing, it was all to be a good fellow. We played tennis together and frankly I admit that I was susceptible.

My neighbor could not tell me what was the matter; he said there were no cracks in the concrete, but the surface was not very smooth, and the fact was that it was just porous. Of course I told him how to plaster the inside of it and patch it up. The next winter when he went south they spent considerable time in fixing it up, to the end that it would hold water and it did.

My friend had been telling me what wonderful grapefruit he had been growing down there. He expected that the trees would begin to bear shortly and I like grapefruit. So on Sunday afternoon we had been out for a walk and coming back home, we found a package leaning against the front door with my name on it. The package contained three grapefruit and I will say that they were good ones.

As I look back at it now, it seems as though I got something else out of that experience, for I decided not to design any more reservoirs or anything else just to be a good fellow, and furthermore, I concluded that it was not best to simply draw up a design and leave the execution to somebody else not under my supervision, who by failure to do good work could bring my design in criticism.

I find that this decision of mine is backed up by the best practice of engineers. Divided responsibility for a piece of engineering work is treacherous to say the least. Of course no one can offer an excuse for doing engineering for nothing.

RATING HIGHWAY CONTRACTORS IN WISCONSIN

By F. M. Balsley, Construction Engineer, Wisconsin Highway Commission, Madison, Wis.

(The following article is from the April number of Public Highways, official publication of the Wisconsin Highway Commission.)

The necessity of qualifying contractors according to their honesty, business ability, good intentions, financial standing, and ability to carry on construction work with speed and efficiency, is now almost universally conceded by those to whom supervision is delegated. This condition was forced on the public after years of costly experience with incompetent contractors who bid on work without any previous knowledge of the requirements, simply to get the jobs. Actual costs seemed to be a secondary consideration at that time, and the result was a large amount of unfinished work, a large number of bankrupt contractors, unpaid bills, and finally a call on the bonding companies to complete the jobs.

A road closed for a long period due to a lack of progress on the part of the contractor affects future construction in that locality because of the crtiticism by the local people. The department is criticized for its lack of judgment, the contractor is roasted, and the people become disgusted with road construction generally and contractors in particular, to the point of refusing to vote for further improvements. This is one of the contributing causes for the demand that construction work be carried on by day labor.

Keen competition at lettings, rigid inspection, and insistance upon strict adherence to the plans and specifications have served to eliminate gradually the inefficient and undesirable contractors. Competition has also speeded up construction until at the present time the season's product per unit is double what it was formerly.

None of our good contractors base their profits on the saving that may be effected by substituting poor materials for good, or lessening the cost of the work by evading the provisions of the specifications. They do, however, rely on their skill and good management to produce the units of construction at a lower price than their competitors. A contractor is a manufacturer in one sense of the word, and if he is to continue in business and prosper he must be governed by the same rules that control all successful business men in other lines. His slogan must be, prompt delivery of first class goods at a price the public can afford to pay.

Rating

Many contractors have been ruined by undertaking more work than they were able to handle efficiently. For this reason we believe it necessary to give each contractor a rating based on his past performance, financial status, and equipment. This does tend to eliminate competition on large projects, but it is, nevertheless, good business, and must be strictly adhered to or disaster will result. No one would think of giving a rush order for any commodity requiring the shipment of a carload per day to a manufacturer whose plant could produce only one-half a carload per day, but that is what is done if a ten mile paving job is awarded to a contractor whose finances, equipment, experience, and management indicate his capacity to be only five miles. We believe that we are doing the contractors of this state a favor by holding them within reasonable bounds on the quantity of work upon which they are allowed to bid. There is a limit to the supervision that can be given by a contractor, and it is not always possible to employ superintendents or foremen who will take sufficient interest in the work to see that it is carried on economically.

Financial Rating

Most of the states require an up-to-date financial statement to be submitted with every bid. This is not done in Wisconsin. Contractors who wish to qualify and who are strangers to us are requested to fill out a questionnaire. This questionnaire covers the subjects of experience, financial status, and equipment. With respect to experience we ask for references as to the class and quantity of work the contractor has been doing. We consult these references, and if we receive a favorable reply from them, and the financial rating is O. K., the contractor is placed on our qualified list for the amount of work his references state they believe he can handle efficiently. Contractors who have worked for us are rated on their past performances without any particular attention being paid to their financial status except in cases where they have failed to meet their obligations. It has been suggested that it would be advisable for us to require a financial statement each year. Undoubtedly this would be the safetst procedure to follow, but it also has its bad features.

In these days of keen competition, a contractor must have enough cash on hand, or credit readily available, to discount his bills and meet his payroll without relying on his first estimate. The morale of the crew is affected if they are not paid promptly, and credit soon vanishes if obligations are allowed to pile up. There is no one feature so important to the contractor as gilt edge credit, and for that reason he should never take more work than he can finance.

Equipment

One of the major items in highway construction is the necessary equipment. There are as many instances of contractors owning too much equipment as there are instances of underequipped contractors. There is too much of a tendency to purchase everything on the market that might come in handy. The items of interest, depreciation and taxes, which are as certain as death, run the operating costs so high that the contractor must bid out of reason if he expects to meet his obligations. If he does succeed in getting a job, and the figure is at all low, his profits are all eaten up before he starts operations. Our most successful contractors are not by any means the ones owning the most equipment. Our successful earth movers did not buy power shovels until they were unable to hire them or until the yardage on the particular job at hand warranted the purchase. Enough equipment in good repair to perform the job is absolutely necessary—too much is a serious handicap.

It is my opinion that successful contractors do not just happen—they are born organizers whose inherent tendencies lean toward construction work. They are judges of men endowed with the ability to select a foreman and workers under him, and so instruct and train them that a smooth-running, perfect functioning organization will result.

Paradoxical as it may sound, our most successful contractors, that is, the best money makers, almost without exception, do the best work, cause the least trouble during the construction period, do the largest amount of work, and are the easiest to deal with in making financial settlement. For the most part they are willing to accept suggestions from the engineering department, and in cases where our advice has been taken they will admit that we have been of service to them. They pay their men good wages, feed them good, wholesome food, give them a comfortable place to sleep, and make it a point to so interest them in the work that they will not only stay through the season but will do their utmost to keep the job going at high speed until it is finished. They are not unduly contentious about small things, and this attitude always redounds to their credit in the long run.

Then there is the matter of personal supervision. I mean what I say when I tell you that the contractor to be successful must live on the job. Contractors have lost large sums of money by taking on more work than they could personally supervise. More than that, they have ruined their reputations. A ship will not follow its course without a pilot. Neither will a contractor's organization continue to function efficiently without the owner's constant supervision. Benjamin Franklin's statement applies here, "If you want your business done, go—if not, send."

During the early period of railroad construction, prices were good and some of the larger contractors expanded to the point of owning a number of complete working organizations in charge of superintendents. Competition was not so keen as it is at the present time, and profits were realized as long as the prices stayed up. Economy and general efficiency are the watchwords of the successful highway contractor, and he finds it a difficult matter to select a superintendent who will handle the work as if his own money were invested in it.

This "hard-boiled" proposition of stating who shall and who shall not bid on public work is a matter requiring fair-mindedness, nerve, and determination. It may be necessary to bar one's best friend from bidding on work he cannot handle, but it must be done if the contracting business is to remain on a business basis.

Now the question arises, what is the man to do who is refused a place on the list of qualified contractors because of lack of experience or equipment? Naturally, he must start as the others did. He should take work from other contractors in amounts he can handle, and gradually enlarge in the way of experience equipment, and available cash. If his work as a subcontractor is good, it will be an easy matter to get someone to back him with a testimonial that will be recognized by those in authority. We need many contractors who are capable and willing to handle small jobs, and all those who have good references are qualified. Remember

that a would-be contractor must have an opportunity and must start somewhere.

We have had a few instances this past season where contractors who were rated high failed to live up to their performances of former years. The causes may be listed as coming under the following heads:

Too much work widely scattered; mismanagement; lack of personal supervision, and poor equipment.

All of these handicaps can be overcome, and they will not occur when contractors realize that failure to function efficiently affects their status the following seasons.

We feel that contractors should welcome any rules or requirements that tend to screen out the undesirables, and we hope to secure their support in cases where drastic action is imperative. The moral effect of setting up definite standards of performance and adhering to them without fear of prejudice cannot help but make the construction field a safer one in which to invest money.

SPECIAL ASSESSMENT BONDS IN IOWA

By H. M. Reed, City Solicitor, Waterloo, Iowa

If a legal discourse, like a sermon, should begin with a text, the proper one for this occasion is found in the quotation, "The sins of the father shall be visited upon the children even unto the third and fourth generation."

Most cities have had an ambitious improvement program which has included the installation of sewer and paving in front of vacant lots. The owners of these lots grew tired of paying taxes, or were unable to pay them, and the lots went to tax sale where they were either not bid in at all or were sold at scavenger sale. Possibly in some instances an assessment was held void in whole or in part by the District Court. At any rate the assessment does not pay out. The contractor who laid the improvement agreed in his contract with the city to take either bonds or certificates for the amount assessable without recourse on the city. He is paid with this paper which he promptly sells to the bank that finances him and the bank sells to its various clients and depositors. Now six or eight years later the time in which the assessments should be paid has elapsed, they are all paid that ever will be, and some of the bonds or certificates issued in payment for the improvement are unpaid. Who stands the loss? Is it the bond or certificate holder or the city?

The situation may vary a little. A whole assessment may be found bad or be enjoined and considerable delay ensue before a new one can be made or the legal difficulties ironed out and the contractor get his bonds. If the interest for this period is not included in the new assessment, who stands that loss? If certain of the assessments are held void by the court because of failure of notice, or because an attempt was made to assess government property, or because an attempt was made to assess for grading, or for any other reason, where the contractor has already taken assessment certificates for the work in full payment and without recourse on the city, who is out of pocket?

What effect does it have on the liability of the city, if any, that it is already indebted to its constitutional and statutory limit? Are these bonds and certificates such an indebtedness of the city as is within the constitutional limitation of debt? Is the city's or town's liability any different on a special improvement bond than on a special assessment certificate?

Asking questions about this subject is easier than answering them, as is frequently the case with interrogatories. But it is a matter that must be considered because a great many of the cities and towns are faced with suits raising some of these very questions. This paper does not purpose to be a brief or an argument, but rather a short and dispassionate statement of what the holdings of our court would indicate the law to be in this State.

The court has squarely held "A special assessment is not an obligation of a city but of each individual property owner." Grunewald v. Cedar Rapids, 118 Iowa 226. It has said that contracts by a municipality, the cost of which are to be borne by property benefited, form no part of the indebtedness of the municipality within the constitutional and statutory limitation thereof. Tuttle v. Polk, 92 Iowa 433; Swanson v. Ottumwa, 118 Iowa 161; 33 A. L. R., 1415. So an improvement to be paid for by the property benefitted can not be enjoined by some tax payer on the ground that the town is already indebted to the constitutional limit. That question has been disposed of in the cases cited. These bonds and certificates are not liabilities of the city in that sense of the word.

But, you say, doesn't that dispose of the matter? If they are not liabilities of the city then, of course, the city won't have to pay them. Not so quick, my friends, and not so easy. The road out of legal difficulties is never as simple as that. The Iowa Supreme Court has held cities liable in a number of instances where special assessment bonds or certificates were issued in payment of the work, and taken by the contractor without recourse. Let us briefly consider some of these cases.

Where a proper contract is entered into, by the terms of which the contractor agrees to be paid in improvement bonds or certificates and relieve the city from liability thereon, the city may be liable to the contractor if, on account of some negligence or oversight on its part, some of the assessments are not legally enforceable. This does not mean the city is liable if the assessments do not happen to be paid. The city merely guarantees its procedure against jurisdictional defects, but does not guarantee the solvency of the property owners.

Barber Asphalt Company v. City of Des Moines, 191 Iowa 762, was the culmination of a series of cases arising out of some paving that was done in that city. The Council failed to give the proper notice to a man named Hurley, and for that reason the assessment could not be enforced. The court says that "The failure of the city to issue a valid certificate was a breach of contract between it and the plaintiff entitling him to damages sustained by such failure."

The opinion does not seem just clear whether it was the written contract with the contractor or the implied contract to deliver a valid certificate that was breached, but at any rate the city was held for the loss and also for the damage sustained by the contractor in loss of interest by reason of the failure of the city to issue the other assessment certificates promptly on acceptance of the work.

In Fort Dodge Electric Co. v. Fort Dodge, 115 Iowa 568, there was the same sort of contract with the paving company, and the Council levied assessments against the street car company which were illegal on account of some franchise agreement. The court says there, in holding the city liable, "If by the wrongful action of the city the contractor is unable to realize on any of the certificates issued to him then we think he has a right to recover from the city. It would not be reasonable to hold that the contractor must know at his peril whether the certificates based on the assessment were valid. He was justified in assuming that the city had made a valid assessment and issued enforceable certificates and if the certificates issued were not valid, then he was entitled to his recourse against the city."

In Pipe & Tile Company v. Callalan and City of Des Moines, 125 Iowa 358, an assessment was held invalid because it was so excessive as to be confiscatory, and the contractor recovered against the city even though he had agreed to take the certificates without recourse because that meant "certificates which are legal and representing an assessment valid and enforceable." The earlier Iowa cases of Bucroft v. Council Bluffs, 63 Iowa 646, and Scoefield v. Council Bluffs, 68 Iowa 695, hold to the same effect.

In these cases although the court said the city must pay the contractor because it made some mistake, he does not collect on the certificate or bond. The basis of his recovery is the error of the city. The court says that the procedure is in the hands of the city, not the contractor. He has no way of telling the city what notice to give or who to assess. Therefore it is the city's duty to see that the bonds or certificates are legally issued and it may be liable for a failure to do so. This is true even though the contract between the city and the contractor says nothing about issuing valid certificates and even though the contractor agrees to take the paper without recourse. Of course the bonds and certificates usually state, "That all the acts, conditions and things required to be done, precedent to and in the issuing of this series of bonds, (or certificates), have been done, happened and performed, in regular and due form, as required by said law and ordinance." (Code 6928). Even so it must be remembered that the recovery in these cases does not seem to have been on the bond or certificate, but rather for the breach of the duty of the city to issue valid paper. Unless the assessment is void in whole or in part there is no liability, because the paper is valid.

As I said before there are many turns in the legal lane. The courts held these bonds and certificates are not obligations of the city. You cannot sue the ctiy on them as you would sue it on a warrant or funding bond, but the city is liable for a failure to issue a valid

certificate or bond. Whether its liability is for the breach of an implied contract to issue valid paper or for negligence is not quite clear. The Iowa cases do not expressly decide this point, and, in one case, it said it did not matter, but there is no liability unless the act complained of was a jurisdictional one and vitiated an assessment.

From the standpoint of the municipal corporation the fact that the liability, if any, is not on the bond or certificate, has at least one advantage. The statute of limitations would begin to run at the breach of the contract or when the negligent act was done, and in most cases would have run before the instrument matured. That is, the bond or certificate holder does not ordinarily realize that the paper which he holds will not be paid until six or eight years from the date of its issue, and by that time a suit against the city would be barred by the statute. This defense of the statute of limitations has not been directly passed on, but would seem sound.

The damage sustained by the holder of the unpaid bond or certificate would ordinarily be the amount of the face of the paper with interest, so that his recovery, if any, would be the same as though a suit were brought on the instrument itself.

The cases discussed here have been those where the court said there was some illegality in the procedure for which the city was responsible, resulting in certain assessments being void and certificates worthless. In the great majority of instances, undoubtedly, the bond or certificate is not paid because certain of the tax payers did not pay their special assessments and when the property was sold at tax sale it did not bring enough to pay them. Here there is no illegality. The city does not guarantee the collectibility of the bonds and certificates that it issued. It merely guarantees their legality. The determination by the council that the assessment is not in excess of the benefit and not in excess of twenty-five per cent. of the value of the property at the time of the assessment is final in the absence of an appeal. It would not seem that the holder of these bonds or certificates could successfully claim in an action against the city to recover the amount of them that the lots were assessed more than they should have been. In most cases that is the only claim they could make, and I do not believe the position is well taken. The tax payer himself can not raise the question except by appeal from the action of the council. Therefore, the certificate holder can not come into court several years after the assessment is made and long after the time for appeal has passed and claim that the city acted illegally or negligently in assessing the lots the amount that it did.

The claim has been made in one of the cases pending at Waterloo that certain of the lots assessed had been sold at tax sale prior to the time the assessment became a lien, and that this purchaser at tax sale ultimately took deed to the lots free of the lien of the special assessments, and therefore the assessment was void. I do not believe this claim is well taken because the city does not guarantee the collectibility of the assessment nor certify that the taxes on the property assessed have been paid. In fact, most of the questions raised by those seeking to recover are matters that interfere with the collectibility, but are not matters of legality and do not render the city liable.

It must be borne in mind that in order for the contractor or his assignees to recover at all there must have been a valid contract. If there is a jurisdictional error in the proceedings prior to the contract or in that instrument the contractor can not recover because the city's liability is predicated on a valid contract. It can incur no indebtedness nor liability for such an improvement without it. Citizens Bank v. City of Spencer, 126 Iowa 101.

Inasmuch as the liability of the municipality is only for errors in proceedings and not on the bond or certificate it would seem immaterial which was issued so far as holding the city is concerned. A reading of either one of these instruments will show that in neither of them does the city agree to assume the obligation or pay any money from its general funds. The certificate might be said to be evidence of the tax payer's debt payable from a particular assessment, while the bond is payable from funds raised by the assessment.

It is possible that a contract for the improvements could be so phrased as to relieve the municipality from liability in every case. On the other hand it might be written to insure the contractor getting his money whether the assessment paid out or not. Undoubtedly in the

majority of cases the contractor takes the bonds or certificates in payment without recourse.

Whether the city officers can be compelled by mandamus to reassess where there is a deficiency would depend on the facts in particular cases. If the council should dogmatically refuse to make any assessment undoubtedly it could be compelled to do so, if action were brought promptly, or a judgment against the city could be obtained.

To sum up briefly: These special assessment bonds and certificates are not municipal indebtedness within the constitutional limitation. The city is not liable on either of them because they contain no promise by it to pay from general funds. Where there is a jurisdictional error in the procedure, after the contract is let, the city may be liable for the damage caused by that error provided the action is not barred by the statute of limitations. It must be remembered that most mistakes in procedure are not jurisdictional defects and the city is not liable.

A paper that is opened with a text should really be closed with a moral: "A stitch in time saves nine." It is much easier and cheaper to avoid making mistakes in procedure than it is to avoid paying for them. The time to consult your solicitor first is before you draw the proposed resolution of necessity rather than when you are served with a notice of suit on unpaid special assessment certificates.

SURFACE TREATMENT OF MACADAM AND GRAVEL ROADS

By G. Hunter Sykes, Construction Engineer, Arkansas State Highway Department, Little Rock, Ark.

One of the most interesting subjects on road building, to road builders, road engineers, administrators and taxpayers, is the salvaging of the numerous water-bound macadam and gravel roads which have been constructed in the past and which are already costing large sums annually for maintenance due to our roads becoming connected and having to carry loads and traffic far in excess of the amounts reasonably anticipated by the public at large, as well as the engineers and administrators who were in direct charge of the design and construction.

Until a road is subjected to traffic greater than approximately 300 vehicles per 24 hours, the gravel road can be economically maintained as a gravel road, but when the average daily traffic exceeds this amount, the maintenance cost becomes excessive and we must build a higher type of road which will either lose our original investment and withstand the traffic under the new conditions, or salvage our original type by supplementing it with a surface treatment, or other satisfactory method.

Highway engineers as a whole have been somewhat to blame for not making a careful study of surface treated roads and applying this method, and have rather fallen in line with public sentiment and tried for higher type roads. Such action is naturally along the lines of least resistance for they have had the backing of propoganda of the cement associations for concrete roads and the asphalt associations for asphaltic concrete roads, who have properly promoted their products and thoroughly sold the idea to the public. It is also true that from an engineering standpoint the higher type of pavement is much more interesting and satisfactory to construct, but if we, as engineers, do our duty and are fair to the public, we will conserve as much of the results of previous expenditures as possible.

Arkansas Conditions

We, in Arkansas, occupy a unique position for the following reasons:

1. We can profit by the expensive experiences of the States who have been in the road building game for a number of years and are now resorting to surface treatments.

2. Surface treatments depend on the use of tars or asphalts in conjunction with crushed stone or gravel. Arkansas is fortunate in having one of the largest single oil fields within her border, and with the local refineries she can take advantage of the low freight rates on the asphalt due to the closeness of the jobs to the refineries.

One of the greatest mistakes which has been made in highway affairs is allowing the public to think of types of construction rather than of the road as a means of transportation. As a matter of fact, the public is not interested in whether it rides from New York to Los Angeles over a concrete pavement, sheet asphalt pavement, asphalt concrete pavement, penetration pavement or over a water-bound macadam road. It is however, interested in riding over a well

maintained road, serviceable every day in the year.

If we can train the public to demand good roads, but not good roads of a certain type, we will be doing them a great favor, save them money, and will be putting the road building of the nation on a scientific basis as it should be.

A few years ago, when surface treatment for roads was in the experimental stage, most people became thoroughly disgusted with the idea because the roads were drenched with an excess of oil, tar or asphalt and it stood in pools to be splashed on every car that passed, and it was impossible to take a drive of over 100 miles without running over one or more sections where the treatment was being applied.

At the present time, however, most of the experiments have succeeded in doing away with the undesirable features and the surface treatment can be applied with very little inconvenience to the traveling public.

Many millions of dollars have been wasted by the abandoning of water-bound macadam and gravel roads of higher types, when in reality, the addition of a surface treatment would have made them satisfactory for the traffic they would be called upon to accommodate for a number of years.

Let us, therefore, study and watch the many miles of water-bound and gravel roads which have been built at great expense, and when the time comes that the traffic shows the present road to be inadequate, let us salvage what we have and surface treat it, and by so doing we can get many years of satisfactory use out of the old road at a very small expense compared with the cost of the new construction of a high type, or even as compared with the cost of maintenance as a water-bound macadam or gravel road.

The surface treatment of macadam and of gravel roads will be discussed separately because different materials and methods are employed in each case.

Macadam Roads

The application of the surface treatment should not be attempted when the temperature is below 50 degrees Fahrenheit, neither should it be done during wet weather if the best results are to be obtained.

All pot holes and irregularities should be patched and the surface brought to proper cross-section, which can best be done by using a macadam binder and crushed stone. Traffic should then be diverted and kept off the road by the use of detours. The surface of the macadam road should then be thoroughly swept with a rotary broom and completed with hand brooms to remove all foreign material.

The bituminous material should then be applied (at the rate per square yard specified for the particular job) under pressure and immediately covered uniformly with crushed stone or washed and screened gravel uniformly graded, of specifications given below under Cover Material No. 1. This cover material should be applied at the rate of approximately seven pounds for each 1-10 gallon of bituminous material. This should be immediately rolled with a self-propelled roller weighing not less than five tons. A gasoline propelled roller is better for the fact that it can be kept rolling continuously. When a steam roller is used, one-third of the time can be figured as unnecessary with the average operator for refueling, one-third of the time for taking on water and it is doubtful if the remaining third will be devoted to rolling.

The application of the first treatment should be continuous on one side of the road, followed later by the application on the other side. After a given section has received its first application it is usually best to follow same with a second application, applied as stated for the first application, especially when the road has not received a surface treatment before. However, where the road has been treated before, usually one application is all that is necessary.

After the surface treatment is applied and the cover material spread and rolled, the project should be maintained by a patrolman who should be equipped with a small portable hot pot, small tools, some bituminous material and some cover material, whose duty shall be to repair all breaks and pot holes as they form in the surface.

Oil for Hot Application, which is satfactory for use in Arkansas, should meet the following requirements:

The oil asphalt should be homogeneous, free from water and shall not foam when heated to 175°C (347°F).

1. Specific gravity 25°C/25°C (77°F/77°F) not less than 1.000.
2. Flash point—not less than 200°C (392°F).
3. Melting point—30°C (86°F) to 50°C (122°F).

4. Penetration at 25°C (77°F) 100 g. 5 Sec.—250 to 300.
5. Loss 163°C (325°F) 5 hours—2 to 5%.
   (a) Penetration of residue at 25°C (77°F) 100 g. 5 Sec. not less than 150.
6. Total bitumen soluble in carbon disulphide, not less than 99.5 per cent.
7. Material for any one contract shall not vary more than 0.02 in specific gravity nor more than 10°C (50°F) in melting point within the test limits specified above.
8. Organic matter insoluble—not more than 0.2 per cent.

Cover Material No. 1 and No. 2:

Passing three-quarter (¾) inch screen, 100%.

Retained on one-quarter (¼) inch screen, 85 to 100%.

Retained on (20) mesh screen, 100%.

Gravel Roads

The surface treatment of gravel roads differs somewhat from the surface treatment of macadam roads, in that the first application should consist of a lighter bitumen in order for it to penetrate into the gravel road. Tars as well as asphalts give satisfactory results, but on account of the proximity of the source of supply in Arkansas, asphalt only will be considered.

The preparation of the road bed to receive the surface treatment is made in the same manner as for macadam roads, then the first application of bitumen or prime coat is applied and allowed to stand open to the elements and sunshine for at least three days, so that the light oils may evaporate, as they are of no use after they have carried the asphalt down into the road bed. Should it be necessary to allow traffic to use the section of road under treatment, it is necessary to use some cover material to prevent the picking up of the prime coat and a covering of No. 1 cover material in the quantity specified above is desirable, which should be immediately rolled. Some bleeding will occur after the first application, due to the cut back agent in the prime coat, and this should be covered daily with additional material to prevent picking up. All loose material should then be removed and the second application made with bitumen described under macadam road surface treatment. The application of the bitumen shall be immediately followed by the cover material No. 2 and thoroughly rolled.

The amount of cover material required will be approximately 7 pounds per 1/10 gallon of bitumen but shall be in sufficient amounts to leave an excess of loose material on the surface to take care of the subsequent bleeding in warm weather.

It has been found that one initial application on gravel roads does very little good and will not last through the season satisfactorily, but when two initial applications are used, it is possible with careful maintenance, that it will last two or three seasons, depending, of course, on the amount and kind of traffic to which the project is subjected.

Oil for Hot Application Prime Coat—50% to 70% Asphaltic Oil 250-300 penetration—50% to 30% Crude Oil or Naphtha vehicle.

Note:—Asphaltic oil 250 to 300 penetration same as given below, for second application plus the crude oil or naphtha.

Oil for Hot Application Second Application shall meet the following requirements:

The oil asphalt shall be homogeneous, free from water and shall not foam when heated to 17°C (347°F).

1. Specific gravity 25°C/25°C (77°F/77°F) not less than 1.000.
2. Flash point not less than 200°C (392°F).
3. Melting point—30°C (86°F) to 50°C (122°F).
4. Penetration at 25°C (77°F) 100 g 5 Sec.—250 to 300.
5. Loss 163°C (325°F) 5 hours 2 to 5 perecnt.
   (a) Penetration of residue at 25°C (77°F) 100 g 5 Sec. not less than 150.
6. Total Bitumen soluble in carbon disulphide not less than 99.5 per cent.
7. Material for any one contract shall not vary more than 0.02 in specific gravity nor more than 10°C (50°F) in melting point within the test limits above specified.
8. Organic matter insoluble—not more than 0.2 per cent.

Cover Material No. 1 and No. 2:

Passing three-quarter (¾) inch screen, 100%.

Retained on one-quarter (¼) inch screen, 85 to 100%.

Retained on (20) mesh sieve, 100%.

An interesting example of the amount of money actually saved by resorting to the bituminous surface treatment may be here stated.

The El Dorado-Smackover road in Union county is of gravel construction,

18 feet wide and 11 miles in length. This project when completed as a gravel road was subjected to the oil field traffic, and based on the traffic census, it was found that 7,500 vehicles of all kinds passed over this project every 24 hours.

During the summer of 1925 this project cost the State on an average of $300 per day for maintenance of this 11-mile stretch with State equipment, and then the road was just about holding its own without any signs of improving.

In the early fall of 1925 it was decided to surface treat this stretch, which was done by State forces with State equipment, at a cost of $1,500 per mile, or about 14 cents per square yard for a double surface treatment. One small gang with a hot patch pot is now maintaining this section satisfactorily at a cost for labor and materials of between $20 and $25 per day and the road surface is improving all the time.

STATE AND LOCAL TAXATION AND BUDGETING

By William Fortune, Indianapolis, Ind.

(Editor's Note: The following address by Mr. Fortune was presented before the Annual Convention of the United States Chamber of Commerce at Washington, D. C., May 13, 1926. Mr. Fortune will be remembered by many of our older readers as the founder and first editor of Municipal and County Engineering.)

We have long heard that there is nothing more certain than death and taxes. It has been believed that death afforded the only legitimate escape from taxes, but victory belongs now to taxes since there has been found a way to tax death. These grim old associates, death and taxes, give us some concern. Death allows some respite, but the tax visitation comes with inescapable regularity and with disturbing demands for more and more.

Taxation has become the biggest born creature of government. It is consuming so prodigiously that we are becoming conscious that it is taking strength from the productive elements of life and may seriously weaken the body it feeds upon unless it can be restrained.

The Growing Burden of Taxation

The signs of danger are before us. The demands of local governments are running ahead of the apparent growth in national income and are swelling out of proportion to the increase in population. In 1917, the average per capita cost of government in 248 cities was $19.07. Eight years later it was $35.76. The total debt in these 248 cities amounts to $105.71 per capita. It is significant that the curve in local expenses continues to be upward.

President Coolidge sees the danger and as a wise leader has, frequently, directed attention to the need of restraint. There is the ring of Providence in his voice of caution. The millions who are paying billions of money feel and know that he is pointing to the vital problem of our times. The millions who give must force heed upon those who take. The cause for alarm is made signifiant by the President's statement that the burden of taxation in our country has grown to such enormous proportions that more than seven millions of our people must earn five dollars a day for three hundred days of the year to pay the amount required for public expenditures. Statistics show that more than one-fifth of all national income is being absorbed in taxes. The President has said that tax collections have grown to over ten billions annually. And yet this isn't enough. This behemoth of democracy, called taxation, seems insatiable. His growing system calls for more and still more. He is feeding on the future by adding to indebtedness of local government around a billion dollars a year. Already the burden put by public expenditure upon every individual in our country has been made nearly six times heavier than it was when the young voters of today were infants, and according to the best available statistical information the total volume of taxation has increased from $875,000,000 in 1890 to $7,907,000,000 in 1924—an increase of more than 800 per cent in 34 years.

How much more can be piled on sagging backs? Shall we go on adding to the load until we break down the burden bearer? The barbarian of the desert wouldn't be foolish enough to so abuse his camel, knowing that if he did he would suffer disastrous consequences. The burden bearer must have some consideration —at least enough to keep him up and going.

There is even more to be considered than the danger of overloading the burden bearer. By extension of paternal service through gradual processes our democracy unconsciously is rapidly becoming socialistic, and this tendency is largely the cause of increased taxation. There is complaint enough to indicate

general objection to excessive taxation, but is there clear understanding by our people of where the cause for it begins and is there willingness to deny themselves enough of the new luxuries and privileges which they are demanding to afford relief from some part of their burden?

How a Half Billion Dollars Can Be Saved

Compulsion of paying for what we get is inescapable, but, as a matter of fact, the public is now paying enormously for what it doesn't get beneficially, and if it will, as it can and should, intelligently require an honest dollar's worth for every dollar it pays, there could be a very large saving, perhaps enough to eliminate the deficits of many thousands of toilers on the farms and in the shops whose margin between profit and loss is so close that a little saving will keep them at least on the right side.

While the main purpose of this discussion will be to direct attention to local expenditures, it is of enough importance to mention in passing an instance of what more may be done in a big way to eliminate waste, improve efficiency and get service more nearly worth its cost in the realm of the federal government. It is the opinion of Representative Davey of Ohio, that a half billion dollars a year can be saved under the provisions of a bill introduced by him and now pending in the Congress, proposing to enlarge temporarily the power of the President of the United States for the purpose of accomplishing reorganization of government service and providing for the elimination of useless government employes and departments. It provides the most practical and effective plan yet offered for eliminating waste and inefficiency in federal government service. There is extreme need for its enactment into law. In the eighteen months ending with last July, in spite of the President's pleas for economy, there was an increase of twenty thousand civilian employes of the government. A saving of a half billion dollars a year will make possible another reduction in federal taxes of about twenty-five per cent more than hase recently been granted, and can be largely turned into improvement of the general prosperity of the country instead of being restricted to the support of less than one-tenth of one per cent of our people. Why should there be hesitation or delay in enacting such a measure into law in a country that should be governed by the people for the people?

The Problem of State and Local Expenditures

In the last few years the federal government has made substantial progress in reducing indebtedness and expenditures, while State and local governments have been increasing both indebtedness and expenditures. There is much evidence of need of further retrenchment by the federal government, but greater need of careful attention to State and local expenditures, as approximately two-thirds of the public revenues are gathered under the powers of State and local governments.

Enough impetus has been given to consideration of the subject of public expenditure by President Coolidge to arouse the public to the need of restraining local waste. If we do not promptly follow up the work that has been so well started by the President we may find that we have neglected our best chance for constructive effort. There is danger that we may so long delay vigorous action that the momentum of the President's initiative may be lost. Delay usually results in fading effectiveness and finally in impotent acquiescence, and thus submissiveness easily permits wrong to become permanently fastened upon its victims. Achievement of what the President stands for will be wholesome for the country. The good of it is far beyond estimate in terms of dollars.

A Crusade Against Waste Is Needed

Mr. T. S. Adams, who ranks as a high authority, attributes wasteful public expenditures largely to indifference or inertia on the part of the taxpaying public. He says, "To overcome this we need widespread and continued study and discussion." An understanding of what we need is an intelligent beginning, but there will be no substantial progress toward improvement until inertia changes to action. The taxpaying public is a sleeping lion. How can it be aroused to action? All the punches given by the President have not been enough to sufficiently force it to use its strength for self-protection.

Primarily, we must realize that the earnest and responsible co-operation of every citizen in his individual functioning is needed to make adequately effective any plan of action. Mark Twain's familiar comment on the weather expresses aptly the futility of the usual discussion of taxation. "Everybody talks about it, but nobody does anything." A crusade

that will arouse to duty every individual is needed.

In a widespread effort it should be the endeavor of everybody to live up to the example of Calvin Coolidge. We should begin with ourselves as stockholders in our biggest corporation, our government. The duty rests on every citizen. It is a patriotic duty. It is for our country and for all our people. We should fight waste as we would fight fire or disease or any enemy of our country. The thought and effort and if necessary, sacrifice of every citizen is needed.

Leaders in the world of business and finance have in recent years applied themselves to the problem of eliminating waste in production and distribution of goods and services. Information abounds to show that their efforts have been rewarded with a large measure of success. Commendable self-interest, even self-preservation in the business world gives the impulse to war against waste and inefficiency. The same productive thought and energy should be applied to opportunities for retrenchment and elimination of waste in public expenditures. Waste in government, though not so direct a charge on productivity, is no less certain in its crippling effect.

Overlapping Taxing Powers

There are complexities within complexities in the problems of both State and local taxation. We are tapping the reservoir in too many places. A tendency to create a multiplicity of local taxing districts has sprung from a variety of causes; sometimes to circumvent a constitutional debt limit, sometimes in an effort to secure freedom from existing political domination, sometimes for reasons of administration only. The result has been to establish overlapping corporations, each within the bounds of the same district, placing its burden of taxation on the same properties. As an instance, there are twenty-eight superimposed tax units in Cook county, Illinois. In a situation of this kind the individual taxpayer must turn to several corporations for relief. He is often confused and handicapped in his approach to the local tax problem. This constitutes a reason for the establishment of a superior body such as a State Tax Commission with power to see that the work of several more or less independent tax levying bodies is properly co-ordinated with relation to the total tax problem.

Much of the complexity of the whole tax problem is due to the further overlapping power of a multiplicity of state taxing jurisdictions. There is but one economic unit and that is our country, but the power of taxation and expenditure is exercised by forty-eight separate and independent states, with little regard for inter-relationship as it effects economic interests, and this forces upon business questions of serious import. It violates economic principles, prevents fair competition, forces business to operate at a disadvantage in some instances and results in waste that falls in some degree upon the whole country. The tendency of this is ultimately toward exhaustion of sources of revenue. There should be co-operation between representatives of the national and state governments in efforts to co-ordinate national and state taxation systems so that duplication and inequities may be eliminated. So much for the problem. Let us now consider the solution of it.

Antiquated Systems of Administrative Service

Much can be gained by substitution of good system of organization and administration, as developed by business experience to supersede antiquated methods of service. In many states time has brought no improvement, but instead has led into patching and extension of service without co-ordination or proper control. State, county, city, town and township government need thorough improvement. There have been some efforts to accomplish this, but few can be considered as thorough enough to be up to modern business standards. The most progressive move has been made in Illinois, where about a hundred departments were, by elimination or co-ordination, welded into a new system of operation. Thirteen states have recently initiated important reforms in simplifying their administrative systems by reorganization and consolidation of departments, bureaus, commissions and divisions. In urging administrative consolidation last year in Minneaota, Governor Christiansen said that the burden of increasing taxation was to be attributed largely "to a system in which ninety-two agencies have an incentive to spend money and no one has power to compel retrenchment." Minnesota now has an executive council and thirteen departments in place of the former patched organization of ninety-two agencies.

After several years of discussion the people of New York State, in November, 1925, voted a constitional amendment

which provides that the present 150 separate divisions of the state government shall be reorganized into not more than 20 departments. Governor Smith appointed a commission, headed by Charles E. Hughes, charged with the responibility of drafting legislation for the reorganization outlined in the constitutional amendment. The Hughes Commission has recently made its report recommending a reduction to sixteen major departments.

Any governor who can bring about the adoption in his state of a thoroughly modernized system of efficient administrative service, will deserve from his people all of gratitude and honor that can be accorded him. He will become a memorable leader of an important new era in the history of his state.

In some of the states there will be constitutional obstructions in the path of progress, and abolishment of unnecessary or inefficient official service authorized in state constitutions may be difficult or may be delayed, but able lawyers sometimes work wonders with baffling constitutions when they try hard enough.

How Indiana Checks Fraud and Mistakes

There are some things that can be done regardless of antiquated constitutions and administrative machinery. All public expenditures can be brought under thorough and searching examination and complete authority can be given for recovery of misused funds. The duty of audit and examination should be compulsory and should embrace all public expenditures. The powers of the agency making examinations should be independent and ample. Responsibility should be absolute. The restraining influence of such oversight is wholesome beyond measure, and it will besides bring back into the public treasury through discovery of mistakes, if not dishonesty, many times the cost of the service. This has been proven by experience.

In the State of Indiana, for example, the Department of Inspection and Supervision of Public Offices has as its principal officer a State Examiner, who, together with the Governor and Auditor of State, constitute the State Board of Accounts. The offices of State Examiner and the State Board of Accounts were created by an act of the legislature in 1909. The duties of the State Board of Accounts are to prescribe and install a uniform system of accounting and reporting for all public offices which will show in clear and understandable form all receipts and expenditures of money; to determine the validity of all financial transactions involving public money; to prescribe the form of all reports and statements required for the internal administration of any public office; to conduct periodic examinations of the finanical operations of every state, county, city, town and township office; to recover all public money unlawfully obtained by fraud, delinquency, negligence, peculation, ignorance or misunderstanding; and to assist public officials by the promulgation of administrative orders, rulings and regulations and the interpretation of statutes under which they work.

Innumerable cases could be cited in which this Board of Accounts has recovered or saved for the txpayers amounts ranging from a few dollars to many thousands. Strict accountability under uniformly systematic practice has accomplished this success. The principle of independent audit is applied just as it would be in careful private business and this accomplishes correction of errors, frauds and dishonesty in the expenditure of public funds.

How Many Millions Have Been Saved In Indiana

This method of course, does not prevent the levying of taxes in amounts greater than needed nor does it affect the issuance of bonds. Many expenditures can be made legally enough which nevertheless do not represent urgent requirements. It has been found that there is need for another administrative device which will curb extravagances which may arise wholly apart from error, fraud or dishonesty.

Under what is called "the Indiana plan" this is provided through state supervision by a State Tax Commission, a part of the duties of which are to restrain unwise or unwarranted use of authority as to proposed local expenditures, bond issues, assessments and tax levies. Reasonable restrictions against interference with home rule are provided, but the commission's jurisdiction is made available when there is appeal from residents of the affected locality. This department is authorized to provide through a staff of experts advice on engineering, architectural, financial, prudential and practical questions applicable to local problems. Service of this kind may not otherwise be available to responsible local authorities without excessive costs. Such supervisory officials

should know from wide experience what are correct standards, fair costs and sound plans of financing, and should prevent wasteful mistakes.

There are many reasons why the State should provide this service for its local subdivisions. It is the practical assistance and co-operation reasonably to be expected from a body exercising powers of supervision in making assessments for purposes of taxation. It may be provided by a State at a cost of a small percentage of actual savings and as a matter of public business is about the most profitable expenditure that can be made. Opposition to the plan on the theory that it is in conflict with home rule is worse than sheer nonsense. The effect of such contention is that local waste and extravagance, even dishonesty, should not be prevented. In the management of private business, branches or departments must be subject to supervision. There is greater need of it in local government where official service is provided through political selection from the ranks of untrained, inexperienced and often incompetent persons who get consideration only by seeking it, and usually are chosen for reasons other than qualification for the duties to be performed. Local government doesn't allow burning houses to be destroyed, if preventable, because the fire started from carelessness of the occupants. The State shouldn't allow its local branches of government to run wild in waste, extravagance and incompetence because unwise, careless or unlucky selection of officials caused the trouble. Authority, responsibility and duty go together in establishing efficient supervision and protection wherever it is needed in the ramifications of State government.

On the other hand, experience has demonstrated that a State supervisory agency is quite susceptible enough to political influences to be responsive to majority sentiment and the tendency is to be very liberal in giving favorable consideration to any proposed local expenditure, even, somewhat unwisely, if there is evidence that it is generally approved in the locality which will bear the cost. In such instances, the extent of supervision will be curtailment of the expenditure rather than prevention of it. A spirit of democracy, it has been found, dominates supervising agencies more than hard-hearted resistance to home rule, and where there is evident general support for any project there is apt to be too easy acquiescence.

Need of Sound Financing Methods

Much of the burden now carried by taxpayers is due to unwise use of credit. There should be greater care in applying sound principles to financial plans of local governments. This can be exercised through a State Commission vested with proper authority. If there must be borrowing in anticipation of taxes, it should not exceed the annual tax levy and there should be no bond issues to provide for the payment of current operating expenses. Bonds issued to provide for public improvements should mature serially instead of depending on sinking fund accumulations for liquidation and the final payments should fall within the reasonable life of the improvement for which such indebtedness is contracted. Refunding of bonds should be avoided if possible. When refunding is necessary it is evidence of unsound financial condition. All of these sound principles of finance can and will be made to apply under the authority of a properly constituted State reviewing board or commission.

The Indiana State Tax Commission, since the year 1921, has been operating under its present powers to reduce tax levies and to reduce the amount or deny the issuance of bonds by local governmental bodies after a hearing upon appeal from remonstrating taxpayers. Between 1921 and 1925, the Commission reviewed on appeal 316 tax levies and ordered reductions in 216. The reductions aggregated more than seven million dollars. In this same period bond issues, totaling $45,358,205 were appealed to the Tax Commission. Of this amount, $26,-944,743 was approved and $18,413,462 was disapproved. A study of the individual cases making up this total discloses that some of the bond issues embraced proposed improvements for which there was small need and in other cases evidence of exorbitant prices was shown.

What the Right Kind of a Budget Will Do

The best device thus far developed by experience for obtaining due consideration and understanding of contemplated expenditures is the right kind of a budget. There are budgets and budgets; some are incomprehensible and some are misleading. Such deserve swift consignment to the waste basket. Any one will know the right kind of a budget on sight. It is all right when it can be understood, and if it cannot be understood it probably isn't right.

Budgeting a government's financial operations means planning a govern-

ment's work. A budget document, therefore, should represent a financial plan comprising estimates of expenditures that are proposed to be made for a given period—usually a year—and estimates of revenues to meet such expenditures. It should be all inclusive as to revenues and contemplated expenditures.

The budget should show under uniform classifications of expenditures all the items that go to make up the total expense of conducting governmental services for the period in question and show what departments, bureaus or agencies are to perform the services. These estimates should be arranged so as to be made comparable to actual expenditures for the same services in one or more previous years.

The best practice requires that the budget be prepared by the chief executive and offered as a program of work which he proposes and for which he will be responsible. A budget message should accompany transmission of the document to the legislative body. A final necessary step in the making of a budget presented by the chief executive is the review and scrutiny by the legislative authority which levies taxes to fulfill the budget's revenue section and makes appropriations to fulfill the expenditure program. At this point opportunity should be given interested taxpayers in public hearing to pass judgment on the budget proposals.

The budget proper should be supported by schedules showing financial condition of the government, existing debt, sinking fund requirements, proposed borrowings, and data showing cost analysis of certain enterprises.

A budget has broad practical value. The preparation of it compels consideration of contemplated expenditures, and the thinking required by it will eliminate in the initial stages much that is unnecessary. There is possibility of some good in anything that will make men think. It was Harrington Emerson, the pioneer apostle of studied efficiency, who was driven to the conclusion that the average man would rather die than think. Perhaps many die because they don't think. Some only think they think, but there is some virtue in trying to think. Elementally the preparation of a budget is a thinking procedure, and has the merit of forcing responsible officials into an orderly beginning of their use of public funds.

It serves an opposite purpose. It affords opportunity to everybody to know quite definitely why taxes must be collected and how the money is to be used. Again it establishes orderly procedure. It doesn't force contention, but it gives a chance for criticism and opposition. If this does not appear at the right time there is basis for the presumption that there is no opposition to the budgetary program of expenditure.

As a matter of fact, it often happens that there is cause for criticism and opposition, but the expression of it has been neglected by everybody, and so politics triumphs over business. Is this because there is more sense in politics than business? It seems so, but it doesn't need to be so. Business is not merely what is going on commercially in the market places. Broadly it embraces everything that materially concerns us, including even taxation and public expenditure. Politics is an appendage of business, but we have been letting the appendage wag the body. If there is too much government it is largely because business has tolerated imposition and fails to use its power intelligently for its own protection.

Every citizen is a unit of business and a participant in its common functionings. If individually and collectively all constituents of government and business, organized and unorganized, intelligently look after their governmental business, instead of allowing it to be managed for them without due regard to their interests, extravagance and inefficiency will speedily disappear from government. Conscious participation will develop better responsibility and more wholesome spirit and should be helpful in bringing about improvement.

The Value of Public Reports

Many cities have made excellent progress in budget methods. One very important development in the budget system remains to be worked out satisfactorily, and that is the need for an improved type of public reporting which will accurately reflect the work that has been accomplished by governmental agencies. Annual or quarterly reports should be prepared with a view to their usefulness in connection with budget making. Local governments should be encouraged to make public quarterly reports on their financial operations and condition. Annual reports should be concise and as brief in scope as may be consistent with setting forth the essential factors by which the government's work is to be appraised.

A business corporation can show its results for the most part in a balance sheet. Profits and surplus give the measure of success or failure. In the case of governments, however, profit is not taken into account; it is service that must be measured. Good reporting requires information as to (1) money expended, (2) persons employed, (3) volume of work performed, (4) work in prospect, and (5) unit costs of doing the work. When the actual performance of divisions of government over a period of years is known through its reports, it will be easy to apply this information as measurements in reviewing budget proposals. With unit costs known, the budget can be made to show in its estimates from year to year so many yards of ashes and street sweepings to be hauled at so much per yard, so many square yards of asphalt paving or patch repair to be laid at so much per yard, so many patients to be hospitalized at so much per patient and so on.

Without accurate "yard sticks" the public is at a great disadvantage in making intelligent appraisal of budget requirements. Large sums of money are spent yearly by civic organizations in making surveys and studies of governmental operations in an effort to find out what the government is doing and what it is costing. Questionnaires, some requiring extensive and costly inquiries, are sent in large number to chambers of commerce requesting facts which would be immediately available without spasmodic and expensive research if adequate reporting on the part of governmental organizations were available.

Reporting methods standardized largely as to content and method of presentation and limited to factors which could be generally agreed upon as being essential, would be invaluable for making comparisons as between results achieved in different cities. Such reports would serve admirably in evaluating the work program laid down in budget proposals. The magnitude of governmental enterprise would justify a thoroughgoing study of the possibility of improving and standardizing information of this kind. Opportunities for using the information abound but the information is not now presented in usable, comparable form. Better reporting is essential to better budget making. The splendid public reporting developed under the leadership of Mayor Jackson of Baltimore, affords an example of what can be done.

Important Service For Chambers of Commerce

The budget system, including public reporting, is essentially a business matter and should be on the program of every organization representing civic and business interest for attention. It *invites* attention. It has come into existence for this very purpose. The budget affords Chambers of Commerce opportunity for very important service. It may be the most definitely valuable service they can render. Some very significant work has been done. In one instance last year there was a saving of twenty-six cents in the tax levy on each hundred dollars of property valuation, amounting to a total of about a million seven hundred thousand dollars, without curtailment of the program of public improvement, and this was accomplished largely through a plan of financing recommended by Chamber of Commerce representatives. Through Chamber of Commerce attention to the local governments budgets there were other large economies, amounting in one year to more than twenty times the financial support given by the community to the Chamber of Commerce which rendered this service. This achievement affords a very substantial and definite answer to the familiar question from members who want to know what is being done to prove that the Chamber is worthy of support.

Every taxpayer can be shown just how much has been left in his pockets as a result of what was accomplished by work on the budget. The head of a large company who was so absorbed in his own affairs that he did not realize what was being done by others for the benefit of the public concluded that he would make a saving by reducing his company's annual contribution of $2,500.00 to his Chamber of Commerce. When the chairman of the membership committee called on him and showed him that he had in hand about forty thousand dollars that would have been collected as taxes if it had not been saved by efforts of Chamber representatives the discussion quickly came to a happy end.

Need of Organized Effort

Why has not all of the protest against waste and extravagance in government been more effective? Why has not something been done in the way of checking the ever increasing burden of local taxation? We have many vociferous leaders, but the plain truth is we are lacking in organized effort to express informed pub-

lic opinion against the growing local tax burden. Governmental spending bodies are organized for the very purpose of spending. Organization is needed for an intelligent exercise of reasonable control over spending bodies. While each citizen must be made to feel his responsibility as an individual to recognize the tax problem and work for its solution, it, nevertheless, is true that individuals must associate themselves in suitable organizations to do the most effective work in attacking the local tax problem. In every community there should be organized effort. Farmers and home owners may be able to make their efforts more profitable than time devoted to the task will yield in any other way, and yet this may be done without interference with other duties. Where there is no organization prepared to give due attention to representing the taxpayers' interest in public expenditures, one should be formed to undertake the work. There are, however, thousands of organizations already in existence that can make themselves more useful and better appreciated by giving effective attention to this task.

In this discussion it may be well to make it clear as to how the poor pay taxes, and not the rich alone. Every citizen pays taxes directly or indirectly, and those citizens of lesser means often suffer more keenly than more prosperous people. Every rent bill includes among other necessary costs, a charge for taxes. The butcher and the baker must pay taxes, and, therefore, in the sale of every pound of meat and every loaf of bread there is a collection of taxes. There are taxes in clothing, furniture, fuel and in the service of public utilities—all must include charges for taxes that are necessarily passed on to the consumer.

Expenditure Governs Taxation

Throughout this discussion attention is being directed to expenditures rather than sources or systems of taxation. It is the expenditure of public funds that creates the tax burden and reduction of expenditure is the only way to gain relief. Expenditure is the cause of the tax burden; a scheme of tax collection thereby becomes necessary. This is not to minimize the importance of studying the kind and character of taxes. But no matter how satisfactorily the system of taxation may be worked out, no matter how equitably it may be distributed, the burden of taxes will still be too great if not every means has been employed to reduce expenditure by elimination of waste and extravagance. Regardless of the incidence of taxes the problem of reducing expenditures remains paramount. It is possible to work on a reduction of expenditure program before the tax system is overhauled, while it is being improved and after the improvement is made. There is no conflict; there is no hindrance; the certainty of gain always is in reduction of expenditures.

Chambers of Commerce and others should study the organization of public business and urge the adoption of state and local governmental machinery, which has been shown by experience to be the most effective. They should insist on the most advanced type of budget and then make critical examination of all financial plans proposed. Finally, they should work unceasingly for the improvement of governmental reporting which automatically will call public officers to account for their stewardship of public funds.

Chambers of Commerce undertake to represent broadly the interests of their localities. They should stand for business enterprise, civic betterment and desirable progress. They may be expected to view liberally and to support earnestly any wise public expenditure for advancement of the welfare of their communities.

They should not adopt a cheese-paring policy of cutting taxes merely for the sake of a lower rate regardless of its effect on public interests; they will stand for cutting waste and unnecessary services but will stoutly defend expenditures for necessary services where there is no waste apparent.

Their membership embraces community leaders of the best experience and judgment and public spirit locally available for service. These are essential qualifications for voluntary advisers representing community interests in considering budgets for expenditure of public funds. Officials should welcome such capable assistance. It enables them to bring into participation in their responsibilities most desirable support. On the other hand, it opens to Chambers of Commerce opportunity to render service of more definitely recognizable benefit than can be seen in other less productive plans.

Can Save a Billion Dollars a Year

Much of the work of Chambers of Commerce has a value not readily measurable. A yard stick can be applied to a budget task and if desired results are achieved the benefits are sizable and realizable—tangible enough to need no

optimistic imagination to comprehend their possibilities. Some intensely practical and direct work of this kind in a Chamber of Commerce program will enhance acceptability of more vaguely general plans of intangible value and will provide comprehensible answer to the inevitable inquirer who wants to know what has been done that it can be shown is worth what it cost. It is service of direct benefit to all taxpayers of every community and for the good of the whole country. It is practical and patriotic endeavor to correct the most alarming faults in our government. It may be the biggest task ever undertaken by an organization, but the objective will be worthy extraordinary effort, and if successful it will be a commendable, substantial and comprehensible achievement.

It is possible to save from waste and extravagance in our government as much as a billion dollars a year. To do this it will be necessary to cut from local taxation about fifteen per cent., but if we include federal budgets an average of less than ten per cent. will be enough to make up the aggregate saving of a billion dollars. It can be done and it should be done without eliminating anything essential and without retarding progress. It may be accomplished through wise economy and better efficiency. "Wise economy" does not mean indiscriminate opposition to public expenditure and does not at all mean opposition to anything that is worthy or sufficiently needed but it does mean that waste should be eliminated. Whatever is taken from waste will be added to prosperity. It may reasonably be expected that prosperity will be more popular with our people than waste and, obviously, will do more good.

An effort to save a billion dollars a year may be a task big enough to be worthy the attention of Chambers of Commerce. What else can be done that will be better for the whole country or what service of more definite value can be rendered to the people of any community than to save for them waste and extravagance many times the amount of their contributions for support of Chamber of Commerce work? If every Chamber of Commerce striving for the welfare and prosperity of its locality will vigorously assume this task, it may be able to point to more substantial results than it can achieve in any other way. A widespread effort under the leadership and direction of a great national organization is needed. If the Chambers of Commerce of the United States can become the means of accomplishing even one-tenth of the possible saving, it will be no mean achievement to be able to show definitely that they have rendered service worth a hundred million dollars. Any organization that can prove that it has rendered service worth a hundred million dollars a year will command great respect.. Committees seeking accession to membership will be equipped with a new forceful and understandable appeal to reluctant and hard-headed citizens who have heretofore failed to be convinced of their duty to support organized civic endeavor. Even a hundred million dollars impresses some people. But, frankly, figures are used only to give tangible form to an important task and to make it comprehensible to everybody. Lurking unrevealed within the bigness of figures is the hope of far greater possibilities for the good of our people and our country. The gain from success will be vastly more than may be realized from merely pecuniary benefits. It will be revealed in a new era of wiser living.

If the twenty-eight hundred Chambers of Commerce scattered over the United States and the 1,440 other business organizations associated with the United States Chamber of Commerce embracing more than a million members, join in the battle against waste and extravagance, something is going to happen. Waste and extravagance and taxes will soon go down. Wiser living and better general prosperity will soon begin to go up. Our country will be better for the renewed and the needed interest in it and concious participation in its affairs by citizens who have too long been neglecting their patriotic duty.

You who are listeners here are the leaders in these organizations. You can start this good work, and if you do, to you will belong the credit of initiative of a great economic movement for common good.

I am telling you not merely what may be done, but I am telling you something of what has been done by a Chamber of Commerce. The feasibility of my suggestions has been demonstrated by the Indianapolis Chamber of Commerce, through the activity of its Committee on Civic Affairs in the work which it has successfully carried on during the last three years.

Consideration of this whole problem is well under way in the Committee on Taxation of the United States Chamber of

Commerce and a report will soon be submitted. A resolution authorizing action has been introduced for consideration here and approval of it by this convention will start through this organization such widespread effort as I am urging.

ASPHALT WEARING COURSES ON GRAVEL ROADS

By G. C. Dillman, Deputy Commissioner-Chief Engineer Michigan State Highway Dept., Lansing, Mich.

(A paper read at 12th annual conference on Highway Engineering at University of Michigan, February, 1926.)

The subject assigned to me, "Asphalt Wearing Courses on Gravel Roads," is one that has not been getting a great deal of attention in the state. It has only been seven or eight years since the first asphalt surface of this type of construction was built on a country highway in Michigan. Until two years ago we had only nine or ten miles in all, this being located in the southern part of the state.

In this discussion I will confine myself to one particular type, namely bituminous concrete with a 2 in. wearing course, constructed on gravel base—this being merely from the standpoint of a salvaging process on the principle that we are getting as much value out of this for each dollar expended as we would for a more expensive type of construction from the subgrade up.

In this particular type of work we must keep in mind that unreasonable and long chances should not be taken. We believe the road we get with this method is little better in the way of strength than the base underneath it. A 2 in. top is not much in the way of thickness and unless you have a foundation well drained and heavy enough and one that will support the traffic it is going to be compelled to carry, it would be the height of folly to try and rejuvenate one of these gravel roads and salvage it with an asphalt top.

Michigan has something like 16,000 miles of improved gravel roads. I would not lead you to believe that we could take all of that mileage and handle it in the manner I am speaking of. The gravel road did very well until the great development of a new kind of transportation came about. I am now referring to the gravel road such as we have throughout Michigan. Our once good gravel surface then began to give way no matter how much was spent on it. The demand is for dustless roads and the county and state must meet reasonable demands of the user of the road. Where traffic is not too heavy we have been quite successful with applications of calcium chloride as a dust palliative. Bituminous treatments have been applied but we have many miles of gravel roads where something more than a bituminous treatment is necessary.

It is a foregone conclusion that we cannot spend thirty or forty thousand dollars a mile to pave all our highways as soon as they need rebuilding or when the public thinks they need it. Our big problem is to maintain these thousands of miles of gravel roads in a safe and satisfactory condition. We shall be able to solve this problem only to the extent of funds made available for changing the natural gravel surface through intensive maintenance with dust layers, asphalt surfaces or building concrete pavements.

Our consideration is confined to the second method, the construction of asphalt surfaces on gravel bases. This is merely one means of salvaging the gravel roads that are worth salvaging. We can build more miles than would be possible were we to confine the work entirely to concrete paving. I do not intend to set this up as being just as good and a road that will last as long as concrete pavement, but I do believe it worth while and we should consider the possibilities of this particular type for quite a mileage of gravel roads in our state.

We must make sure that the gravel road is well built, has ample depth of well compacted gravel not less than 5 or 6 in. in thickness determined only by testing the depth of the metal on the road. We must go right onto the job and make the test holes and determine the actual depth of gravel as it exists. Speculation on depth of gravel should have no part in this investigation. We must have a stable foundation with the best of drainage provided, ample width of metal, usually 16 to 18 feet, and satisfactory grades. The grade cannot be changed when carrying out this method of construction because as soon as you do that you run into an expense that this type of work does not warrant. The road should have a good cross section.

After it has been decided to surface the road with asphalt, we then begin the most intensive maintenance. The best time to begin such work is in the fall or early spring.

Before beginning the actual paving operations, a power grader is used to put the road grade in as near perfect condition as is possible, the aim being to make the base conform to the finished crown of the surface. A template is used. It is important that the cross section be very close to what is ultimately hoped for in the finished surface and it can only be determined by means of a template.

Any irregularities that have not been taken out of the surface through the blade work and patching with gravel are taken out by means of a black base or binder course (perhaps this can be confined to patching only) and this is an exceedingly important step.

After the gravel base has been prepared we then come to the application of bituminous material. To keep the gravel surface free from dust and to hold it intact so it will not be kicked up, it is necessary to tie it down in some manner. We apply about one-quarter to one-third gallon of bitumen to the square yard. So far we used only refined tar, but the proper grade of asphalt would no doubt be all right. Allow sufficient time for the oil to evaporate before surfacing operations begin. Surface treating the base is a new idea. It was not well taken by some of our department engineers at first, but it finally was proven that it was the logical thing to do. It provides a dustless surface and makes possible the construction of an asphalt wearing surface without any great difficulty in carrying on the work.

It is necessary to do more or less patching when hauling the bituminous mix over the surface treated road. The thickness of the black base or binder course varies from practically nothing to 5 in. and in some instances 8 in. All loose gravel is dug out and filled in with this mixed material. A black base beam is built in connection with this patching and is a part of the job, it being 6 to 10 in. in width on each side. In other words the base will be 6 to 10 inches wider on each side than the finished surface. That conforms with the idea carried out in Ohio when reconstructing and widening some of the macadam roads in order to give additional supporting power. In order to proceed with the wearing surface we must have some means of holding the hot mix material so it can be handled and rolled. Wooden side forms are placed along the road, lined up and spiked down by means of steel pins 12 or 14 ins. long and ⅞ in. in diameter. In this way the ultimate profile of the finished road is very little different than the gravel road after it is surface treated or when it is being prepared for the wearing course.

No doubt many of you have driven over some of the asphalt work done during the last few years and found that the riding qualities compare favorably with the concrete pavement. You have perhaps noted the rolling grades and as explained to you, these grades cannot be changed without going to an unreasonable expense.

Great care is taken in the sand grading. A man is constantly at work testing the sand and taking temperatures at the plant, the data being recorded daily. The surface, when completed, will run from 2 to 2½ ins. in thickness. The raking must be carefully done and a back-man is kept to take care of any honeycomb places if such develop during the rolling. We use four rollers on this type of construction—first a 5 ton power roller with a straight roll, then a 1,500 lb. hand roller for a cross-roll. This is followed with an 8 ton roller and a 12 ton roller. The 5 ton roller is used again after the hand roller, making a diagonal roll. The 8 ton roller makes a double diagonal roll and then straight rolls the entire surface which is followed up with a 12 ton roller for a slow straight roll. The instructions are to move slowly and accomplish what is desired. We half lap each roll. The 12 ton roller is kept busy until it can make no further impressions on the surface. A straight edge is used on the surface behind each roller and any low spots filled and the high spots rolled out. The next step is to broom the dust on the finished surface and we have the road complete so far as the wearing surface is concerned.

We are not going to the expense and effort of building shoulders, as we have on cement concrete pavements; however, shoulders of good width are constructed.

It is impossible to alter the grade very much, although we are building shoulders of reasonable width and flatter slopes and take care of other minor details.

This work is all done with free labor on state force account. So far we have not contracted any of this type of construction. Our superintendent has had considerable experience wtih this work and his standing instructions are that he is to turn out nothing except A No. 1

work. An office is maintained on each job with a paymaster and clerk always present. The crew consists of a about 110 men, this being comprised of 31 plant men, 34 street men, 27 men on the grading crew and a truck crew of 15 men. The plant we have been operating for the past two seasons is of the semi-portable type equipped with an oil burner drum, boiler, cookers, asphalt pump, tool furnace, air compressor, fuel tank and asphalt tanks mounted on flat cars. The street equipment consists of one 12 ton Tandem power roller, one 8 ton Tandem power roller, one 5 ton power roller, one 1,500 lb. hand roller, turntable, tank wagon, Dodge pick up, rakes, shovels, etc., and nine trucks. The grading outfit consists of a Fordson tractor, grader, four Ford trucks and small tools.

We have only recently purchased a second plant and that will be in operation during the coming season on trunk line 14 south of Jackson.

Reports are turned into the office each day by the plant and street foremen. A consolidated report is made up weekly and a summary report is made to the main office.

During the past two years we have completed approximately 27 miles of this type of construction. It may be of interest to know that for every 17 sq. yds. of surface an average of one ton of black base material is used. The output of the plant that has been operated for the past two years has amounted to from 1,700 to 2,000 sq. yds. of surface per day.

A few words about what the work has been costing may be of some value. Our 1924 and 1925 work necessitated three plant set-ups involving six projects having a length of 27 miles in all. The width of asphalt surface was either 18 or 20 ft., and the average cost per mile for the first four jobs when completed was $14,390. The first job built cost only $12,062 per mile. This work was on trunk line 43 between Kalamazoo and Richland and was completed during the year 1924. The next project was east and west of Sturgis on trunk line 23—also a mile just west of Bronson. The third project was near Moore Park on trunk line 13 extending from Three Rivers north to the St. Josph-Kalamazoo county line—also a short section north of Schoolcraft. All of this type of construction has been confined to the southwestern part of the State and three counties.

I would like to point out that on some of the work the additional cost has been entirely due to the large amount of black base material needed. This average cost of $14,390 per mile noes not include allowance for use of equipment except for repairs and replacements that have been necessary while the equipment was being used on the various jobs. You can readily determine about what would be added to the cost of this work for use of plant and street equipment which makes the ultimate cost very reasonable considering the type of road built:

In conclusion I believe that this type of construction is a practical means of salvaging many miles of gravel road and where traffic conditions warrant, it is a good investment. I would, however, have you understand that this type of construction cannot be carried out at random throughout the State because only when the gravel road is built and maintained properly and where we do not expect a great deal of heavy trucking can this type be used effectively. It necessitates careful manipulation of the details of construction which are many and we must not be afraid of spending money for strengthening the gravel base and widening it if necessary.

OPTIMISTIC VIEW OF PUBLIC INDEBTEDNESS

By Melvin A. Traylor, President First National Bank, Chicago

(From an address at 49th Annual Convention American Bankers' Association.)

Another group of our citizens, wise, cautious and sane, who may be seeing things, are those who believe that the country is headed toward finanical ruin through a debt taxation. No one will deny that these items are assuming staggering proportions, but when we examine the other side of the ledger, is the situation as bad as it appears?

Have we not forgotten the growth of the country?

Do we properly appreciate the change that has taken place from the forest and pasture of 150 years ago to the agricultural supremacy of the last quarter of the nineteenth century, and again to the industrial achievement of the present day?

One hundred years ago government was a simple matter. The population was small and thinly scattered over great areas. The pioneer was busy subjugating the new lands, building homes and bringing the natural resources of the country under his dominance.

The expense of administration then was small.

But as the population increased, as cities and towns were built, as the work of the pioneer was largely finished, and as great industrial centres grew up, the regulation and direction of our daily activities became more and more complex and government became an ever-increasing and expanding function and a consequent growing charge. Statistics are overwhelming as to the increase of our national wealth and national income. Our mounting debt may be tremendous, the taxes we pay may be burdensome, but is the debt out of proportion to our wealth and our ability to pay?

For what, after all, are our debts created?

Those of us who have been taught prudence and caution in the matter of borrowing money usually say that a debt should not be assumed except for productive purposes, but if we will carefully analyze our own case we shall doubtless be forced to admit that some of our most satisfying possessions are those acquired through the purchase of non-productive property.

What Is a Safe Debt?

No one would maintain that a home is a liquid or renumerative asset, and yet it's the ownership of a vine, a fig tree, and a roof all our own that gives a sense of security and pride and a joy that nothing else can produce.

Home ownership is eloquently advocated as a panacea for many of the ills of the present day, and yet we know that this end can only be accomplished in any large way through the assumption of individual debt.

The one safe guide for the contraction of such a debt is the reasonable assurance of an income which will meet the charge of the loan and ultimately accomplish its liquidation.

If we can justify individual expenditures for non-productive purposes for the personal welfare of the individual, does it require any violent wrench of economics to find a warrant for the expenditure in behalf of the community for community welfare?

Excepting the war debt, which was gladly and willingly assumed by all, I think it is safe to say that a large part of new securities emitted in recent years has been of a municipal character.

Has the issue of these securities gone too far, and has the purpose for which the money has been expended justified the debt?

Why Return to the Oil Lamp and Mud Roads?

A writer recently contributed an article to a western paper, entitled "What's Eatin' Us." He rightly, I think, attributed our panic of seeing things to a lack of proper appreciation of the blessings we enjoy.

Among other things he said:

"To those who remember the time when $40 an acre was considered an outrageous price for land in eastern Iowa, a spring seat on a farm wagon a luxury, and the possessor of a 'top buggy' a nabob; when there was scarcely a furnace or a bath tub in the entire state of Iowa; when the only refrigerators in town were those in the butcher shop; This Age when one only has to touch a button to get a light with the strength of a hundred candles; when you turn one faucet and get cold water and turn another and get that which is hot; when houses without bathrooms and furnaces are exceptions; when schoolhouses in small towns are better appointed than State Capitols used to be; and country children are taken to and from school in auto buses, and city schoolhouses are not considered quite up-to-date unless equipped with a swimming pool; when workmen drive to their daily tasks in gas cars; and there are enough autos in Iowa to take every man, woman, and child in the state out for a joy ride at the same time, it seems as though some genii had rubbed a modern Aladdin's lamp and that we are living in Fairyland.

"The truth is that these things handed to the young people of today are the results of toil and thrift—the subjugation of a wilderness—by men and women, who asked only a chance to try their strength, and to the triumphs of science and the discovery of truth. To this pampered generation these facts, the toil, the sacrifice, the hardships and privations are unknown. The rich heritage is accepted as a matter of course—often without so much as a thank you, and frequently with complaint because there is not more."

Homes Must Shelter a Happy People

If national life is to survive and be happy—and it will—the homes of the city, town, and the country must shelter in pleasure and comfort a contented people.

This can only be done by capital investment that cannot be made, with rare

exceptions, in one lump sum from accumulated savings.

Good Roads Add Value

Who of us now would willingly return to the conditions of 50 or 100 years ago?

Much of our recent debt has been for good roads. In most parts of the country these cost in the neighborhood of $25,000 per mile, but they add immediate increased value of $10 to $25 per acre to every foot of land they traverse, and they certainly add increased dollars to every item produced on farms bordering or near them, to say nothing of the comfort and happiness which safe and easy traveling over them brings to the rural communities.

Would we stop building roads and would it be a good investment to do so?

As the writer just quoted says, borrowed money has gone into the erection and equipment of splendid school buildings in city, town and country. Would we like to go back to the little red schoolhouse with one window, an oil lamp, a single blackboard, and a three-foot rule, which might be used for more than one purpose?

We would not, and we will not.

A very large sum has been and is being borrowed by the farmers of the country to pay existing debts, to purchase more land or to improve and equip the property which they already own.

Would we have it otherwise?

Governmental vs. Corporation Loans

We don't hesitate to approve the borrowing of money by our customers, firms or corporations for the purpose of plant expansion and to meet the increasing requirements of their growing business. We purchase and freely distribute the securities of our railroads and utilities for the construction of magnificent stations, terminal facilities, and business homes, many of which are in themselves decidedly non-productive.

We measure the soundness of these enterprises by the yardstick of an ample excess of value over debt incurred, and a satisfactory income, to provide with reasonable certainty, for the service and amortization of the loan.

If we applied the same yardstick to the municipal and farmer debt, which are causing many of our citizens such concern, is it not clearly and easily to be seen that these debts too, are equally jutified and secured?

Capitalizing Appreciated Values

Most of our states have very salutary laws regulating the issuance of securities by the states themselves and the subdivisions thereof. These are based upon sound principles of ample property values and wise tax limitations.

The difficulty is that we cannot realize that each increase of a million population adds just so many units of additional demand for each foot of soil and homes for human existence. We are not willing to concede that the community is justified and should capitalize a part of that appreciated value for community welfare.

The farmer who borrows $50 per acre upon his land is merely capitalizing a part of the value which has accrued to him through the ever-increasing demand of an increasing population for the purpose of contributing to his individual and family comfort.

We Lend and Borrow from Our Friends and Selves

There is, however, another element which robs this bogey of increasing debt of much of its alarm for me; that is, that all of the securities issued are being purchased by our own people. We are simply borrowing from our neighbors and paying back to them. The increasing wealth of the nation is being spent in making the nation a better and happier place in which to live.

If we were impoverishing ourselves by the sale of our securities to others and the payment of large sums as a charge thereon to foreign people, we might well be disturbed. But the debt is our own and we in turn own it, and better still we are not borrowing to make these security investments. They are being made from accumulated earnings, from the savings of the people, and still are not absorbing all these savings or accumulations, as is witnessed by the constant increase in savings deposits amounting to more than 10 per cent annually, to say nothing of the tremendous increase in current bank balances.

We are rapidly becoming a nation of investors and property owners, and cry aloud as alarmists may, I do not believe you can make bolsheviks of such people.

CONCRETE TESTS IN NEW JERSEY

[Editor's Note: The following article is from "Public Roads" for April, 1926.]

The New Jersey State Highway Department, in cooperation with the Bureau of Public Roads, has begun a series of concrete tests for the purpose of studying the relative concrete making proper-

ties of crushed stone and gravel used in concrete road construction in that State. The tests are being made in the State Highway Laboratory at Trenton, and involve the fabrication and testing of about 250 concrete beams 8 by 8 by 48 in. in size, as well as a large number of cylinders for compression tests.

The program calls for three series of tests. In the first series the workability of the concrete is to be kept constant, as nearly as possible, by means of the flow test, and the relative yield and strength of the concrete determined for each of several gradations both of crushed stone and gravel, using concrete proportions as given in the current New Jersey Standard Specifications. The object of this series is to determine the relative strength and yield of gravel concrete as compared with crushed stone concrete for several sizes and gradations of coarse aggregate.

In the second series an effort will be made to design concrete of a given strength by means of the water-cement ratio theory, for each type and gradation of coarse aggregate. The procedure to be followed in this series is essentially as follows: To each gradation and type of coarse aggregate, fine aggregate will be added in the following ratios by volume, 33 to 67, 36 to 64 and 40 to 60. To each of the above combinations water and cement in fixed ratio, depending on the strength desired, will be added until the desired workability has been reached. The end point in each case will be determined by means of the flow test, supplemented by the judgment of experienced concrete operators. Concrete specimens will then be made up in the proportions as determined by the trial method referred to, and the comparative strength, which should be constant, the comparative yield, and the comparative absorption will be determined.

In the third series of tests, specimens will be made in which the concrete mixture has been designed in accordance with the fineness modulus theory as given in "The Design and Control of Concrete Mixtures," a publication recently issued by the Portland Cement Association. The results obtained from this series will be used as a check against the results obtained in the second series.

Assuming a constant strength and a constant degree of workability, it is hoped to determine by means of these tests what grading of coarse aggregate and what proportions of fine to coarse will give the greatest yield of concrete for both crushed stone and gravel.

HIGHWAY RESEARCH IN NORTH CAROLINA

By C. M. Upham, State Highway Engineer of North Carolina, and Director of Highway Research Board, Washington, D. C.

The North Carolina State Highway Commission, being keenly alive to the economic value of highway research in its large construction and maintenance program, has a number of research projects under way, of which the following may be of interest:

North Carolina has for four years been constructing in the coastal regions of the State a type of pavement composed of a mixture of asphalt and local sand. This is known as a sand-asphalt pavement and consists of a bituminous base, composed of from 6 to 9 per cent bitumen and from 91 to 94 per cent sand, and a wearing surface of sheet asphalt. This surface utilizes local sand also, and for this reason a wider range in the screen tests of the sand is allowed than is generally the case in sheet asphalt construction.

North Carolina has been practically alone in the development of this type of pavement and, therefore, a great amount of study and experimentation has been necessary to make this type a success. From year to year, as our knowledge of this type of road increases through study and the building of experimental sections, the specifications are changed to fit our expericence.

The problem of regulating or controlling transverse cracks in reinforced and plain concrete roads has been discussed frequently, but no control of the cracks has occurred to date. With this in view, an experiment was tried on one of our State projects in order carefully to study results under normal working conditions. In this experiment our idea was to control or localize the cracks by introducing planes of weakness in the slab during construction. It was decided to introduce these planes of weakness by means of wooden strips at 40-ft. intervals throughout a 2,000-ft. section of a reinforced gravel concrete road. The section selected was on more or less poor subgrade, being part gumbo clay and part loam not very well drained. It was noted at the end of the curing period that at each plane of weakness the slab had cracked

and the crack ran through to the subgrade. Another inspection, made seven months later, showed that at all the planes of weakness there were open cracks, and in nearly every instance the crack continued 4 to 6 in. out into the shoulder dirt. No other cracks appeared in the 2,000-ft. experiment section and were numerous both on tangents and curves on the remainder of the project, which is nine miles long. As this road has gone into its first winter free of cracks other than at the planes of weakness, we feel that a little progress has been made in the right direction. It will be carefully inspected again this spring for further results.

The object of another experiment was to determine the value of expansion joints. The road selected for this work is in very flat country and, due to poor lateral drainage, the moisture content of the subgrade is exceedingly high. The experiment was made by installing ½ in. bituminous expansion joints spaced 40-ft. centers for one mile of road. Immediately adjoining this, one mile of pavement was built without the use of expansion joints. On the next section of two miles in length the expansion joints were placed on 30-ft. centers. Thus far practically no cracks have developed in any of the above three sections.

Our method of treating the North Carolina soil roads, such as sand clay, topsoil, shale, chert, marl, spar, etc., is meeting with a measurable success. This treatment gives results similar in appearance to sheet or sand asphalt. The treatment consists of first applying a prime coat of a specially prepared tar, which, after being covered with sand and opened to traffic for a period, is followed by a top treatment of a specially prepared asphalt, which is also covered with sand. The road is then complete for the first year, but is given careful maintenance. One treatment is applied annually for four or five years. In this way a surface mat is built up to a slab thickness, which furnishes a satisfactory roadway at low cost.

There arises from time to time certain construction work, on which it is highly desirable to shorten the curing period of concrete, so as to inconvenience the traveling public as little as possible. We have in a few instances on such occasions increased both the quantity of Calcium Chloride and cement in the concrete mixture, which allowed us to open up pavement to traffic after about one-third the usual curing period had elapsed. Cores are taken and observations made on roads in which Calcium Chloride is used in order to determine the effect of this admixture on the resulting concrete.

STATE HIGHWAY MAINTENANCE WORK IN INDIANA

By A. H. Hinkle, Superintendent of Maintenance, Indiana State Highway Commission, Indianapolis

(From a paper read at 12th Annual Purdue Road School.)

Six years ago the Indiana State Highway Commission took over a system of roads afterwards known as State Highways. To comply with the law, this system of roads reached every county seat and every town with more than 5,000 population. After the roads were designated as State Highways, the State became responsible for their construction and maintenance, including the bridges, guard rails, marking and signing and other features required to produce and maintain a system of highways that would satisfactorily and safely carry the traffic.

The development that has taken place on this system of roads in the short period of time is very marked. Although some of the roads taken over were in very good condition and have not been changed much, this can not be said of a larger part of the mileage. Many of the roads taken over in the sparsely settled district were trails. Few through routes were suitable for traffic during the good season of the year and practically none were passable their entire length during the winter, spring, or early summer.

The Construction Division has paved nearly a thousand miles of roads. The bad gaps in the through routes have been improved with stone or gravel when not paved. The narrow roads have been widened. Continuous maintenance throughout the year has been kept up on practically the entire system. As a result we now have a system of about 4,000 miles of state road that are not only passable throughout the year, but are for the most part in excellent condition much of the year. This transition has been brought about in the face of an increase of traffic during the six years of 100 to 200 per cent. Some districts in the state have been opened to a method of transportation that is developing them rapidly.

We have usually gauged our field men

by the condition in which they kept their roads. This was the greatest stimulus for maintaining a good road. The experiences of some of our men and even hardships suffered by them in the first years of the work are hardly known. One may learn of these best while chatting with them as soldiers do, who narrate their experiences about the campfires.

Type	Brick	Cem. Conc.	Bit. Conc.	Bit. Mac.	Sur. Treat. Mac.	Stone	Gravel	Earth	Misc.	Total
Miles when taken over	41.0	96.7	7.5	24.0	68.8	796.1	1,892.7	264.7		3,191.5
Miles Jan. 1, '26....	68.6	933.8	26.0	172.8	23.7	.7	1,629.0	60.9	20.8	3,935.3

In this brief paper, however, we will not dwell on such matters, but will jump from peak to peak getting a birdseye view of some of the work accomplished, now and then dropping down to look at a detail which may be of special interest or value to those engaged in road work.

Organization of the Division of Maintenance

When the Division of Maintenance was organized in the early part of 1920 there were five District Engineers and 25 Superintendents. The road mileage in the state system has increased and our organization has increased to take care of this mileage until we now have 6 District Engineers and 32 Superintendents. The organization has remained constant since 1923. On Oct. 1, 1925, our records showed that we were employing 69 foremen, 247 patrolmen, 266 teams with drivers, 41 skilled laborers, 28 tractor operators, 454 truck drivers, 964 common laborers, 13 roller operators, 7 miscellaneous positions, or a field force of 2,134 men. This does not include the mechanics and their assistants in the local garages, as these are carried on the motor transport payrolls.

The Division does much of its work by contract and the percentage of such work determines the number of employees carried on the state payroll. During the rush period in the late fall and early winter of 1920, we had nearly 5,000 employees on our payroll. This rush of work was brought about by the delay in our new organization getting under way, and also because of the demand to put as many roads as possible, that had just been taken into the state system, in passable condition for the winter and spring season.

Miles of Road in the State

The work done by the State Highway Commission in the past six years is shown in a general way by comparing the lengths of different types of surface in the state system when taken over by the whole department and with lengths now. (The comparison shows the work accomplished by the whole department, and not merely that of the Division of Maintenance.)

We have recently compiled the lengths of all types of roads in the State by county, and further classifying them as State, county and township. This is the most complete report on the lengths of the several classes and various types of road that has ever been compiled. We might say that it is the only complete report of its kind that has ever been made. Copies of this table will be furnished by the State Highway Commission to interested county officials.

The tendency seems to be for the counties to take over more, if not all, of the township roads. While one of the incentives for this is to get a greater portion of the gas tax, this transition will no doubt result in better and more economical road maintenance in many of the counties.

From the point of view of convenience and accessibility, the county is now not as great as the township was 50 years ago. This same comparison might well be made between the county and state. Fifty years ago, to go from the average county seat to the far corner of the county by horse drawn vehicle, took as long as it now takes to go by auto over the state roads from the State capitol to the border of the State.

This is only another way of saying that the world is getting smaller from a transportation point of view. Some one has rightfully said that the average man's sphere of acquaintance has within the past 15 years increased from 10 miles to 100 miles.

For these reasons the state should no doubt take over more miles of the county roads. The Federal Highway Law permits Federal Aid on 7% of the roads of the state. Our new compilation of all roads of the state show a total of 73,111 miles. This would permit Federal Aid

on 5,118 miles. Certainly this is the minimum that should be in a state system. However, the larger the mileage that is maintained, the less the paving that could be done each year. This factor *must* be recognized in considering the greater mileage.

Activities and Responsibilities of the Division of Maintenance

The activities of the Division of Maintenance are many and varied. One who thinks casually of road maintenance seldom realizes the great variety and classes of work carried on today to maintain a state wide system of highways, in safe and suitable condition for traffic all seasons of the year. Of course, a large part of the work consists in keeping the road surface smooth and suitable for traffic. However, some of the other work is quite as important, if not on such an extensive scale.

The gravel and stone roads must be coated with metal and systematically dragged; the cracks and joints in the concrete and brick roads must be filled with bituminous material; small holes and depressions in these two types of roads are patched with the same kind of material; parts that are broken through to the base must be replaced with new concrete; the bituminous roads are patched with bituminous material and maintained with surface treatments; shoulders and ditches must be sodded and maintained; ruts along the edge of the pavement filled with stone, slag, or gravel; weeds and grass must be cut; snow must be removed from the surface to make passable for winter use; the drainage systems, both surface and underground, must be kept free from obstructions so they will operate; old and narrow culverts must be extended or new ones of proper length installed; and the old steel bridges must be refloored and repainted from time to time. As features of safety, to take care of modern traffic, guard rails must be built and maintained; these, together with headwalls and other obstructions along the road, should be painted white, or whitewashed from time to time; narrow fills must be widened; sharp curves reduced; and, last but not least, an effective system of signs and markers installed to guide traffic and aid in preventing accidents. No small part of the responsibilities of road officials is the keeping the right-of-way clear of undue encroachment by the property of public utilities, such as poles, tracks and other obstructions which are frequently erected so close to the traveled way as to be a great source of danger. A constant warfare must be waged against oil pumps, filling stations, hot dog counters and fruit stands, which are continually installed too close to the traveled way. They are a source of great danger because of insufficient space in front of them to accommodate parked machines without interfering with traffic.

It will thus be seen that the work of a highway maintenance organization is not merely the dumping and spreading of gravel, as one high official ignorant of road work, one time expressed himself. If the road maintenance organization is doing its duty, it must function in all the above features. While it is all the time looking in one direction, fighting for its rights which are the rights of the citizens, it must at the same time be looking in the other direction, showing a glad hand and a friendly smile to that ever complaining class of citizens who think the highways are not in such good condition as they should be even though they themselves never done a single act in all their lives that contributed to the provision or upkeep of a better road.

The responsibilities of the County Highway Superintendents, in maintaining a system of county roads, involve not much less difficulty than the maintenance of a system of state roads.

In enumerating the duties and responsibilities of a maintenance organization, I have said nothing of the constant warfare waged by some material interests to have *their* material used instead of a competing product. I believe that the only solution for this problem is that the road official, whoever he may be, should recognize all the advantages and disadvantages of any material and then choose the one from which, with all this information, he believes the taxpayers will receive the greatest benefit. He should be sure that his conclusions are not prejudiced and that he has recognized all the various factors in choosing the most economical material. A road official cannot dodge the responsibilities which are his and he should be loyal to the position he holds, rather than to some selfish interest which would sacrifice him in taking an undue advantage. My own experience has been that, although material interests battle hard for supremacy, they are usually not so ungrateful as often assumed, and while they insist on selling their goods as any business concern would, they are not blind to acceding to

the loss of a sale when a public official is in the right.

Accidents on State Highways

The Maintenance Division attempts to make a report on a blank form for this purpose, of all accidents occurring on the State highway system. These accidents are reported for statistical purposes with a view of learning, so far as possible, the cause of accidents. It is hoped that every means possible may be used to reduce them. We do not permit these accident reports to be used in damage suits. We believe that our men would hesitate to furnish their best opinion of the cause of accidents if they knew their statement would be subject to public inspection and possible legal action against them if they were not able to prove their statement.

Every effort is being made by the Highway Commission to eliminate from the State Highway those physical conditions which contribute to accidents. This past year, the Maintenance Division alone has eliminated 12 grade crossings with railroads, by relocating the highway. The importance of eliminating these crossings on our heavily traveled roads is demonstrated when we learn, that of the 103 accidental deaths on the state highways this last year, 37 deaths, or over one-third, were caused by accidents at grade crossings. Frequently it is found that a grade crossing can be eliminated by relocating the highway for a much less expense than building a subway or an overhead. Many times the only opposition to such elimination comes from the few residents who live along the old location. It is desired that every county official will use his moral influence, although his county may not be able to help financially, in bringing about the elmination of grade crossings.

Work Accomplished by the Division of Maintenance In 1925

The work of the Maintenance Division is distributed over about 4,000 miles of road and is continuous over this mileage throughout the year. Hence, this work is so scattered that the average citizen does not realize that the aggregate of work done is so large. This is best brought home to us when we examine a summary of the work done, materials used, etc.

Our records show that during the past year, besides maintaining the entire 4,000 miles of state roads and bridges thereon, this Division completed the construction of 24.9 miles of bituminous macadam; 19.9 miles of stone road on an earth foundation; 9.3 miles of gravel road on an earth foundation; and rebuilt 18.3 miles of old road as a new gravel road; and rebuilt 66.6 miles of old road as a new stone road.

In the regular routine of maintenance work 106.5 miles of road were given a surface treatment of bituminous material.

During the year this Division constructed 61 new bridges, also slab top and box culverts; installed 474 new pipe culverts; 48 box and slab top culverts, and 231 pipe culverts were extended. Nearly 4½ miles of guard rail was constructed; 80 temporary bridges, aggregating a length of nearly a half mile, were built to accommodate traffic around bridges under construction.

During the year the Division used nearly 1½ million tons of stone and gravel, ⅞ of a million feet of lumber, 1¼ million gallons of bituminous material and 3¾ miles of culvert pipe.

Cost Accounting

A very good cost accounting system has been established for keeping a record of all expenditures. Every payroll and invoice has on it a distribution blank. This provides for the assigning of the expenditures to a specific section of road wherever practical. Certain expenditures, such as salaries of the supervising force, workmen's compensation, certain equipment charges, etc., are difficult to assign to a specific section of road. Such charges are assigned to a Sub-District, a District, or the Central Office with a view of attaching every charge to its specific source so far as possible. Most of the expenditures, however, are assigned to a specific section of road and such charges are sub-divided into Surface, Roadbed, Structures and Snow Removal. In this Table of Expenditures is given the amount of material used on each section of road and a brief statement of the work done thereon. Thus a very complete history of each section of road is recorded each year in the Central Office.

DETERMINING WATER WASTE BY NIGHT FLOW

By William Luscombe, Vice-President Gary Heat, Light and Water Co., Gary, Ind.

(From a paper before the Indiana Section of the American Water Works Association.)

In the discussion of this subject, the writer desires to stress the fact that it

is so closely allied to and interwoven with that of waste and losses in the distribution system, one cannot fully discuss the first without considering the others, so he asks your kind indulgence for the latitude taken.

In determining the night rates as well as the day flows, he desires to emphasize the importance of first knowing the accurate quantities pumped or flowing into the force mains and distribution system, the entire 24 hours. Regardless of what devices, apparatus, or methods are used, frequent accuracy tests and check-ups are essential if correct information is always to be obtained.

In many cities and towns the total output is based according to the number of pump strokes which are taken at face value. In other places allowances are made for slippage ranging from 5% to 20% or more. Some years ago, the writer was in charge of a plant where that method of computation was used. Five per cent allowance was made for pump slippage when he assumed charge. Shortly afterward tests were made and 14% slippage was found in one pump and 18% in another. This condition is typical and "Old Man Slippage" is still doing a "kidding" business and his proportions are such an unknown quantity in many places that he is responsible for a vast amount of misinformation in recording the total water supplied.

In other places and, no doubt, in many instances where special metering devices are used to record the total supplied or pumped, one might well question whether or not its efficiency equals approximately 100% throughout the 24 hours. The showing may be all that could reasonably be expected under a day flow or a peak load rate and yet make a miserable record under a low night flow. This has been the experience of the writer and he believes it is not uncommon. In justice to manufacturers, it should be stated that, on account of the wide range of conditions under which some metering devices operate, it is hardly fair to expect them to make a 100% record all of the time.

What Becomes of the Water Pumped at Night

When the actual amount of water pumped or flowing into the distribution system during the night time as well as during the day period has been accurately and definitely fixed, an analysis of what becomes of all of it may be in order. For the purposes of this discussion, remarks will be limited to that part of the demand made between midnight and 6 a. m. During 1924 our daily average pumpage was approximately 5,200,000 gal., practically all taps are metered, and our population is about 80,000. The percentage of the total pumped per 24 hours, that passes out of the system between midnight and 6 a. m. during non-sprinkling months, ranges from 12.7% to 16.6% and averages 15%. The variations are due principally to changing business conditions, seasons of the year, etc. For instance, during extreme cold weather the night flow is increased as much as 20% on account of customers permitting faucets, etc., to run to prevent pipes and fixtures from freezing and bursting. On hot, dry evenings, when lawn sprinkling is carried on extensively, the rate per minute delivery for short periods is six times as great as that of the latter part of the night flow which, however, is not affected by that use.

Users of Night Water

As mentioned, the demand for the six hour period ending at 6 a. m. averages 15% of the day's total (5,200,000 gals.) or 780,000 gals. Our records show that an average of 84.5% of total daily average pumpage or 4,394,000 gals. is registered by meters on customers' service pipes plus small miscellaneous uses. This leaves a balance of 806,000 gals. per day which we consider chargeable to "unaccounted for" or leakage in mains and services. To ascertain the estimated leakage in mains and services during the 6-hour period, one-fourth is taken of the 806,000 gals., which is 201,500 gals. If this amount is deducted from the total pumped during the 6-hour period (780,000 gals.) there are left 578,500 gals., or about 74% of that total which it is estimated passes through customers' meters during that period.

According to inspections made, the principal users of water between midnight and 6 a. m. are: Industrial and ice manufacturing uses, locomotive tank filling, garages, dairies, bakeries, hospitals, industrial workers' homes on account of time in changing shifts, lunch rooms, hotels and soft drink places.

Recently, it was found that about 20% of the night flow was being registered by five meters of the users mentioned.

Unsuspected Waste Paid For Creates Dissatisfaction

Of course, some of the foregoing list of users, as well as other customers, are also water wasters as they permit such

fixtures as faucets, drinking fountains, closets, urinals, etc., to run continuously, but as they pay for all water furnished by meter measurement, the waste inside of building is curbed to a great extent.

Granted we are paid our regular meter rates for all water furnished the consumer, we take the position that unsuspected waste paid for by him creates dissatisfaction and, in a friendly spirit, we make it our business to show him, if we can, the cause of the high bill so that he will be better enabled to apply the proper remedy. We believe this cooperation and voluntary service is invariably appreciated.

Checking Up on Unmetered Users

Another form of waste that vitally interest us, of course, is that of the unmetered class, or losses in the distribution system and the best method of checking it.

We make frequent pipe line leakage inspections and as many leaks exist that give no surface indications, we have experienced men who use metal rods for sounding locations of mains and aquaphones to locate breaks.

We also ascertain the extent of the leakage into some suspicious sections of the distribution system by closing the gates, using the hose from one fire hydrant to another, and measuring the flow into the segregated section through a meter connected into the hose line.

We obtain very good results with both methods.

Pitometer Tests Preferable in Determining Waste

For extensive water waste surveys, no doubt, pitometer tests are far preferable.

In fairly comparing the percentage of that portion of the total pumpage termed "Unaccounted for," it should be borne in mind there is a great variation in the pressure carried in different cities and towns, and it is very important that this item be taken into account as well as other factors such as mileage of mains in their various sizes; number, size, and mileage of service pipes; percentage of taps metered, etc.

The writer believes that the extent of distribution system losses, or the percentage of water "unaccounted for" in any water plant depends largely on the interest displayed and action taken by those in authority to check it.

THE SANTA CRUZ (CALIF.) WATER SUPPLY

By H. S. Williams, 135 Martin Blvd., Santa Cruz, Calif.

(Paper read before California Section of the American Water Works Association at Santa Cruz, Oct. 15, 1925.)

Santa Cruz, being a very old town, one of the oldest in the State, has conditions to contend with which make the question of civic improvements probably more complicated than most of the newer cities. It has sprung up from a small village on the banks of the San Lorenzo River to an incorporated area of over 8 square miles. Within this incorporated area and at widely divergent points municipal improvements were made in a small way. Apparently extended developments were reached by trail. Later the trails became a semblance of roads which eventually became streets. This process of evolution is apparent all over the present city as indicated by irregular streets and blocks. With this as a base engineering problems have been difficult and the costs of improvement have necessarily been made higher than similar ones in our modern cities.

The newer cities have had only the first cost to consider, while Santa Cruz has the cost of the old along with the new development. Also its early improvements were in the nature of experiments because methods and materials had not been standardized. Santa Cruz has paid high for these experiments and for the most part they must be done over. But with all this Santa Cruz will be made to conform to its beautiful surroundings and its irregular streets will add to its beauty.

Selecting the Santa Cruz water supply as my subject it will be necessary to go back to the small village on the banks of the San Lorenzo River. They had to have a water supply to fill their needs. It was small and probably crude but it filled their requirements. As the little isolated portions of the city were formed they needed water, but with each development there was really no supposition that Santa Cruz would some day be one fairly large city.

With each new development a small water main was extended and down through the years to the present time the scattered portions have increased till now we have a fairly united city. Along with this, small water mains were extended till now we have an intricate sys-

tem of lines too small to function properly for our present day requirements. There was no blame to be centered on anyone connected with it, it just naturally grew and grew till now it is inadequate and the people of Santa Cruz realize it.

The system must be reorganized. Larger mains must be installed in order to reduce the extremely high pressure now made necessary.

In 1923 the citizens of Santa Cruz voted bonds in the amount of $400,000 for the betterment of our water supply, and the new Bay Street Reservoir at a cost of $186,000, together with the necessary pipe lines at a cost of $116,000 leading down from the hills represent the greater portion of the amount used from that source. Then, too, there is the new pumping and filtration plant on the San Lorenzo River. The first represents the complete control of the natural flow of the old sources of the cities' water supply, viz, Liddell Springs, Laguna Creek and Major's Creek. The latter represents an augmented supply of 2,000,000 gals. at a cost of $31,000 and was installed hurriedly in order to overcome the water shortage of a year ago.

The Bay Street Reservoir, the floor of which is at an elevation of 346 ft. above the city datum, or 246 ft. above sea level, occupies a seven acre tract on Bay Street. It is 32 ft. deep and has a capacity of 36,000,000 gals. to the lip of the automatic spillway and a total capacity of 39,600,000 gals. It was constructed on a practically level piece of ground and the excavated material was used for the embankments.

The embankment was built up in 6 in. layers of the clayey material and properly sprinkled, after which it was thoroughly compacted by the use of Fordson Tractors, provided with Sheep's Feet, which produced a wonderfully compacted structure.

This fill was carried 2 ft. inside the proposed base for the concrete lining on the side walls and afterwards trimmed to that line; thus providing a thoroughly compacted support for it.

The base of the embankment was provided with 4 and 6 in. drain tile, surrounded by crushed rock to provide against possible over-saturation of the fills.

After the excavation had been completed, small springs made their appearance and it was thought advisable to install an adequate system of drains as a protection against upward pressure of the water against the floor lining. Trenches were excavated and 4,000 feet of 4-in. tile and several hundred feet of 6-in. were placed and covered with broken rock. All these lines converged and the water carried away through pipes below the outlet tower.

The lining, which is 6-in. in thickness and reinforced with ½-in. bars, 12-in. centers, was placed in 30 ft. square panels on the floor of the reservoir and in 15 ft. panels on the side walls. All the panels were supported on 12x12-in. reinforced concrete beams laid flush with the earth face for the lining. All the concrete panels on the side walls which stood at a 1½ to 1 slope were placed under forms and thoroughly rammed. The expansion joints between all panels were filled with a composition of asphaltum and infusorial earth. The top ½ in. of the surface of all the concrete was made of a mixture of 1 part of Portland cement to 1½ of sand and thoroughly troweled to form a hard finished surface.

The proportion was such as to give a concrete of approximately a 1:2:4 mixture, maximum density being of prime importance in all the concrete used in the construction of the reservoir.

It might be interesting to know quantities of materials entering into this structure. They are:

Crushed rock	146 car loads.
Sand	70 car loads.
Cement	48 car loads.
Steel	9 car loads.

Underneath the outlet tower there was installed an independent outlet to be used for draining and cleaning the reservoir. This outlet tower is provided with screens and the valve control chamber where water is distributed to different parts of the city is located outside the embankment. Two pipes leading to the city from the reservoir were installed. One for the down-town area, which occupies an elevation of about 115 ft. above city datum and the pressure to this area is reduced by the small High Street Reservoir, which occupies an elevation of about 320 ft. above city datum. The other and larger pipe was intended for our bench areas which occupy an elevation of about 290 ft. above datum. It was intended this larger pipe should provide satisfactory pressure for the bench areas and be independent of

the down-town requirements, there being too much difference in elevation between the two areas to provide satisfactory pressure from one source.

The new pipe line consisted of 9,200 ft. of 22-in.; 4,800 ft. of 14-in.; 16,000 ft. of 10-in.

Sources of supply were:

Laguna at an elevation of 710;
Liddell Springs 680;
Major's Creek 450;

and they total about 4,000,000 gals. per day capacity, and the Bay Street Reservoir is located at an elevation which will take all of Major's Creek and at the same time is high enough to give proper pressure to our higher bench areas. Incidentally the per capita requirement of our city is 200 gals., which is high and is due to our truck farming and poultry industries.

Santa Cruz has two situations to meet at the present time. One is to make a complete survey of existing pipe lines within the city so that a comprehensive study of the situation can be made. From this study enlargements can be made where necessary in order to furnish water under lower pressure and in sufficient quantities.

The other is to make a complete study for an additional water supply to meet the demands for years to come. The San Lorenzo River, in my estimation, solves the problem and filings have been made to protect that source. All other sources should, of course, receive careful attention.

We are favorably situated as regards water supply for all our needs and it only requires that we make up our minds to work out the most feasible system with cost and supply as the prime factors, and to coordinate our various systems to the best advantage possible. A plan must be developed now before all our natural sources are exhausted and that plan rigidly adhered to through all administrations.

If we see perfect systems in other localities, it is because those people worked out a plan and adhered to it. It takes good, hard concentration to make an economic study of the requirements of our municipality for years to come, and a fixed purpose to carry it out. It will not stand for political issues nor administration changes. The measure of its success will depend upon our willingness to have the plans laid out well in the beginning. In a measure we get what we pay for and it depends a great deal on how much energy and money we put into this study, how much we get out of it.

To insure the carrying out of a fixed plan it might be well to establish a water commission, the members of which should be elected for a long or overlapping periods and whose duty it would be to look into the establishment of a fixed plan and to see that it is carried to a successful finish.

URBAN ASPECTS OF HIGHWAY FINANCE

By Jacob Viner, Professor of Political Economy, University of Chicago

(Reprinted from "Public Roads" for January, 1926.)

The tremendous growth in recent years of motor transportation has made necessary a great increase in expenditures for rural highways. Such expenditures for the United States as a whole now approximate $1,000,000,000 annually, and appear to be stabilized for the time being at this level. To a large and growing extent the funds for these expenditures are obtained by the special taxation of motor vehicles, in the form of Federal excise taxes on motor vehicles and parts, passed on in part in the form of Federal aid to the States for highway purposes, and of State motor-vehicle license and fuel taxes. In 1924 the special taxation of motor vehicles produced revenues equal to about 45 per cent of the total expenditures of the country as a whole for the construction and maintenance of rural highways, exclusive of interest on highway indebtedness, and the percentage has been steadily rising each year. It will in all probability reach 50 per cent in 1925.

The Federal excise taxes and the State motor-vehicle license and fuel taxes within each State apply equally to automobiles of the same class regardless of whether they are owned and used in cities or in rural areas. The other sources of rural highway revenues are predominantly State and county ad valorem taxes on general property and bond issues, and the bond issues will in the main be redeemed with funds derived from property taxation or from special taxes on motor vehicles. State and county levies on general property are, with only two exceptions of importance, applied to urban and rural population at uniform rates within each taxing dis-

trict, and in these two instances the rates are higher on urban than on rural property. It follows that urban dwellers and urban vehicle owners make the same contribution per unit of property and per vehicle of the same class to the cost of financing rural highways as do rural dwellers. It is possible from available data to estimate roughly the relative amounts contributed to the costs of rural highways in the form of motor-vehicle taxes by rural and urban vehicle owners.

Urban-Owned Motor Vehicles 60 Per Cent of Total

The Federal census for 1920 shows that on January 1, 1920, there were 2,285,531 automobiles and trucks on farms. The total registration of motor vehicles for the country as a whole in the course of 1919 was 7,565,446, and in the course of 1918 was 6,146,617. Assume that one-seventh of the vehicles registered in 1918, or 878,088, were scrapped during 1919. This would make the number of vehicles in existence on January 1, 1920, 6,687,358, or the registrations during 1919 minus the number scrapped during 1919. On this basis the proportion of urban to total vehicles on January 1, 1920, was approximately 66 per cent. Some allowance should be made, however, for automobiles owned by rural dwellers who are not farmers and by residents in villages and small towns properly to be included as part of the rural area. It is estimated that this would reduce the percentage of urban-owned to total vehicles to 60 per cent, and it would be inferable that urban vehicle owners contributed in about the same proportion to the motor vehicle tax revenues.

To obtain an exact figure, further corrections would have to be made. The average motor-vehicle tax paid per vehicle is much greater for trucks than for passenger cars, and on January 1, 1920, only 6 per cent of the motor vehicles on farms were trucks, as compared to 11.7 per cent of the registrations in 1919 in the United States as a whole. Variations in tax rates combined with variations in percentages of urban to total vehicles as between different States, possible variations in the average payments of gasoline taxes between rural and urban vehicles owing to different annual mileage per vehicle of these two classes of vehicles, and possible variations in the average license fees paid by rural and urban passenger cars because of differences in the type of vehicle commonly owned by rural and urban dwellers, respectively, are further factors affecting the estimate here made of the proportion of the motor vehicle tax revenues paid by urban-owned vehicles. These factors, however, probably tend in the aggregate to increase rather than decrease the proportion contributed by urban vehicle owners. If there has been no substantial change since 1920 in the proportions of rural to urban vehicles, the estimate of 60 per cent as the proportion of motor vehicle tax revenues contributed by urban vehicle owners is a conservative minimum estimate. On this basis of calculation, urban motor-vehicle owners contributed approximately $260,000,000 in motor-vehicle taxes to the financing of rural highways in 1924.

Urban Use of Rural Highways

It is protested in many quarters, and especially by municipal officials, that this is an inequitable situation and that urban dwellers should not be required to pay the bulk of the costs of rural highways, especially since rural dwellers make little or no direct contribution to the costs of urban streets. The volume of protest is steadily growing, and, as will be shown later, it has already resulted in some States in a measure of reorganization of the highway finance relations of State and city, and county and city governments. Defense of the maintenance of the existing relationship is most conspicuous on the part of the motor interests. They oppose any diversion of highway revenues from the State or county treasuries to the municipalities on the grounds that: (1) It would tend to retard the State and county programs of highway construction and maintenance; (2) the highway improvement program of cities is less elastic and flexible than the rural highway program, and the cities will procure funds by some means or other to carry out at least the major elements of their programs; and (3) the transfer of highway revenues from the State and county treasuries to the municipalities will not relieve the urban motor-vehicle owners as such of any special tax burdens which they already bear, since urban streets are now financed only to a negligible degree by special municipal taxation of motor vehicles. These arguments, and especially the first two, have a considerable measure of validity, but they appeal to reasons of expediency and not to the fundamental equities in the situation.

To the protest that it is inequitable that urban property owners and urban motor-vehicle owners should be forced to contribute to the cost of rural highways at the same rates per unit of property or per vehicle as rural property or vehicles, while, on the other hand, rural property and rurally owned motor vehicles are not required to make any direct contribution to the costs of city, a more cogent reply could be made if it could be demonstrated that traffic on rural highways consists predominantly of urban vehicles, whereas but a slight percentage of the traffic on city streets consists of rural vehicles. Statistical data on these points appear to be sadly lacking. Of the many city traffic surveys which were examined, there was not one which attempted an estimate of the percentage of motor traffic on city streets which consisted of foreign vehicles. Municipal highway officials who were consulted confirmed, however, the common impression that the great bulk of the traffic on the streets of the large cities consists of local vehicles, and that the percentage of rural vehicles on the streets of great cities is at any one moment negligible.

For the percentage of urban vehicles on rural highways the lack of statistical data is almost as complete. A test count made in 1922 on the rural highways of Davidson County, Tenn., in which county Nashville is situated, showed that 70.4 per cent of the vehicles were city owned as compared to 29.6 per cent owned in the country. An inquiry made under the same auspices indicated that the annual mileage per vehicle on rural highways was for urban-owned vehicles 40 per cent that of rural-owned vehicles. The percentage of urban vehicles to total vehicles on the rural highways should be higher in the immediate neighborhood of cities than on portions of the rural highway system distant from any city. On the other hand, the annual mileage of urban vehicles on rural highways should be greater for vehicles owned in the smaller cities than for vehicles owned in the great cities, where the mileage of street pavements is greater and access to the rural highways is ordinarily more difficult.

The Davidson County, Tenn., data can not be applied, therefore, to the metropolitan problem without important qualification, but they do indicate that a substantial fraction of the traffic on rural highways consists of urban-owned vehicles. Confirmation is supplied by the results of an earlier test made on the rural highways of Iowa, which has no large cities. On these rural highways test counts indicated that intra-county traffic from town to town plus circle traffic from town into country and back to town was 30.4 per cent of the total traffic. To obtain the total percentage of the traffic which consisted of urban cars it would be necessary to add (1) urban vehicles going from town to farm, urban vehicles going from farm to town, (2) and urban vehicles on longer trips crossing county and State boundaries, for which data were not separately gathered. Search for further data on this point was unproductive of results.

Traffic Counts Suggested As Basis of Cost Apportionment to Rural and Urban Uses

If the principle be accepted that the costs of financing rural highways should be borne by the users thereof and should be apportioned among the different classes of users in proportion to their use thereof, urban and rural motor vehicles should contribute to the costs of rural highways in the proportions of their respective average annual mileage on such highways. It would probably be impossible in practice to secure comprehensive and unbiased mileage data of this character if it were to be used as a basis for the apportionment of motor-vehicle taxes, but the same purpose could be adequately served if at periodic intervals traffic counts were made on rural highways to ascertain the relative proportions of urban and rural traffic and the costs of rural highways were met from motor-vehicle taxation apportioned to urban and rural areas accordingly. If it were disclosed by such traffic counts that the relative use of rural highways by rural and urban vehicles was substantially different from their relative contributions to motor vehicle tax revenues, adjustment should not be made by differentiating in the rates of State taxation as between urban and rural vehicles, since such differentiation would open the path to serious political dangers, and in any case would probably be held unconstitutional in most of the States.

A more desirable procedure would be, in case it were found that the contributions of urban vehicle owners were more than proportionate to their use of rural highways, to refund to the city treasuries from the motor vehicle tax revenues suf-

ficient to equalize the ratios of contribution to the ratios of use. On the other hand, if it should be disclosed that urban vehicles are contributing less than in proportion to their use of the rural highways, which in the light of the scanty evidence available scarcely seems likely, adjustment could be made by contributing more generously out of the State revenues to the cost of rural local or secondary highways used mainly for local rural traffic. In all cases account should be taken of the relative contributions of urban and rural areas to the State and county highway funds by means of property and other taxes as well as by means of motor-vehicle license and gasoline tax. As a rule, road district taxes and special assessments are in rural areas now used only in the financing of local roads which serve primarily local needs and are not used to any appreciable extent by urban vehicles. But where primary highways are financed by these methods credit should be given to the rural areas for their contributions in this form.

State and County Grants to Cities for Highway Purposes

In a number of States grants are made by the State out of its highway funds to the cities for use in financing city streets. The treatment in this respect of large cities is often different from that accorded to small towns, and we will deal first with the cases in which cities over 30,000 in population receive State aid for street purposes from the State, either immediately or intermediately through the counties, and either in the form of appropriated grants or by permitting the cities to share in the motor vehicle tax revenues. Most of these instances are of very recent origin and are the result of pressure from the cities for a share in the motor-vehicle tax revenues, but some of them are of long standing. While the list which follows may not be quite complete, it is believed to include all of the more important instances.

Alabama: 20 per cent of the net receipts from State motor-vehicle licenses collected within muicipal limits is returned to the municipality where collected.

California: 50 per cent of the receipts from State motor-vehicle and gasoline taxes is returned to the counties. The city of San Francisco, which is also the county of San Francisco, and apparently also the city of Los Angeles, through the county of Los Angeles, share in the State motor-vehicle revenues through the apportionment to the counties.

Colorado: 50 per cent of the motor vehicle license fees and the gasoline tax receipts collected within each county is returned to the county. Denver city and Denver county are coterminous, and Denver city therefore receives 50 per cent of the State motor-vehicle tax revenues collected within its limits.

Maryland: The city of Baltimore, which is a separate unit in the organization of the State, receives from the State 20 per cent of the State motor-vehicle revenues.

New York: New York City, as a unit in the county organization of the State, receives 25 per cent of the State motor vehicle registration fees collected within its limits.

Ohio: Cities receive 50 per cent of the State motor-vehicle license fees collected within their limits and 30 per cent of the gasoline tax receipts.

Oklahoma: 90 per cent of the State motor license fee receipts is returned to the county where collected, and 25 per cent of the county's share is returned to the cities and towns within the county.

Pennsylvania: Philadelphia, which is coterminous with Philadelphia County, received in 1925 a grant of $250,000 from the State motor license fee receipts.

Wisconsin: The State makes grants to cities out of its highway fund as follows: (a) City streets connecting portions of the State highway system, $300 to $500 per mile, depending upon the classification of the streets; (b) other city streets, cities with population over 10,000, $100 to $200 per mile of street, the amount per mile increasing with the population.

Other Forms of Aid to Cities

In a few instances State aid is given to large cities for highway purposes in other ways than by grants or by refunds of a fraction of the motor vehicle tax receipts. In Alabama, Iowa, and Kansas the State shares in the cost of construction of highways within city limits which connect the street system with the State highway system. In Washington the State pays the cost of maintenance of State highways within city limits. In other States, as, for instance, California for one State route passing through Los Angeles, and Louisiana for two State routes passing through New Orleans, the State in exceptional cases contributes to the cost of specified State routes passing through or on the outskirts of large

cities. As a general rule, subject only to occasional exceptions under special circumstances, all other States require the larger cities and towns to finance from their own municipal funds the pavements which are connecting links in the State highway systems.

In general, also, the counties make no contribution out of county tax revenues to the financing of the streets of large cities, though the situation is complicated in a number of instances by the merging of the county with the municipal governmental organization. Three exceptions to this general rule have been found, however. In Arkansas and Florida the counties turn over to the cities within their limits for street use part of the proceeds of the county road taxes. In the State of Washington 50 per cent of the cost of arterial streets in excess of assessments against neighboring property is borne by the counties or the districts with which such streets connect. Nebraska presents an exceptional instance of the reverse character. Not only do the State and the counties make no contribution to the financing of the streets of the larger towns, but the cities of Omaha and Lincoln are required to contribute out of city funds 50 per cent of the cost of construction of outlet highways outside their limits but adjacent thereto.

These various grants from State and county funds in aid of urban highway finance follow no uniform rule, and there is no evidence which indicates that the basis of apportionment of the State and county funds between urban and rural purposes has in any instance been determined by consideration of the respective ratios of urban and rural use of the highways and urban and rural contributions through taxation to their support. In a number of the instances cited cities share in the State motor vehicle tax revenues only because of the accidental fact that the municipal and county organizations have been merged or are coterminous. These grants are not very important even in the aggregate, an examination of the detailed evidence indicating that they did not exceed $20,000,000 in 1923 for all cities in the United States having a population of 30,000 or over.

Small towns, and especially those under 2,500 in population, receive more generous treatment. It is the general rule or the frequent practice in a majority of the States for the State itself to construct or to provide funds for the construction of standard sections of State highways passing through towns not exceeding a specified population; in some cases maintenance also is provided by the State. This is a desirable practice, if for no other reason than to provide a safeguard against serious impairment of the efficiency of State highway systems through the persistence of unpaved or unsatisfactorily maintained sections within the limits of small towns. In a few States, especially in New England, small towns receive aid from the State in financing their general street program, whereas larger cities receive no such aid. This may perhaps be justified on the ground that for very small towns the town limits are not to any appreciable extent traffic boundaries, and common financing with the surrounding rural highways is logical. In States in which the county is an important political unit it would be more desirable that any aid given to small towns for their general street program should be given by the county rather than by the State. Such streets, like local rural roads, render little service to the dwellers in large cities, and they should not be made, through their contributions to the State tax revenues, to contribute to their support.

CONTROL OF STREAM POLLUTION

By C. M. Baker, State Sanitary Engineer, Madison, Wis.

(This article by Mr. Baker is from the May issue of "The Nation's Health.")

Man's wants and desires are measured largely by things unattainable or at least difficult to secure. Commonplace things are little noticed and of little consequence until gone, then we want that which we had but did not keep.

Great forests covered our land a few years ago but have been cut down and sawed into lumber or, through chemical processes, converted into paper or other wood products for the benefit of man. In this process of deforestation little or no consideration has been given to leaving conditions so that nature could recover from the devastation. Slashings have been left to dry and form a regular tinder for the careless match or camp fire resulting in conflagrations sweeping the areas after the large timber has been cut thus killing all vegetation and preventing the growing of other trees to replace those cut down. Deforestation has prob-

ably been a greater factor in changing the character of our streams than all the pollution entering them. Streams that formerly were abundant in trout now contain none of these magnificent game fish because the shade of the trees and the cool springs resulting from the water held back by the forests are not available to furnish a cold clear water but instead the stream is now one with a heavy precipitous run-off at times of storms and a low, sluggish, flow of tepid water during the dry periods. Not only do such conditions affect the fish life of the stream but they also materially change the character of all other animal and plant life in it. In the advancement of civilization, great centers of population have been developed, encouraging industrial development. The advantages of streams both for water power and as an outlet for wastes have been pointed out as assets to encourage industrial development which has ultimately resulted in changing these naturally pure streams to those harnessed and controlled by man and defiled with pollution by wastes from his industries. Great centers of population resulting in congestion and the discharge of large volumes of human wastes into streams have been the greatest factor in the transmission of diseases, not only those water-borne, but all communicable diseases. Agricultural developments have caused changed landscapes, added to the pollution of our streams, and materially changed their character.

Now with the building up of great centers of population and industries, man is demanding the pristine beauties and advantages which he formerly had, is demanding that our streams be returned to their natural condition and that the forests, now gone, be restored that he may have both the pleasures of city life and of nature in her original state.

In studying the effect of pollution, one must consider the uses made of streams since this not only influences what may be considered objectionable pollution but certain uses are incompatible. The common uses of a stream may be listed as follows: (1) Human consumption as for drinking; (2) production of food as for watering stock, irrigation, and propagation of fish; (3) disposal of wastes such as industrial wastes and municipal sewage; (4) production of power; (5) transportation; (6) recreation, including fishing, particularly for game fish.

All of these uses will more or less interfere with the use of a water for drinking purposes. In fact, it may be considered that no surface water supply is satisfactory for domestic purposes unless purified both by filtration and sterilization. Disposal of industrial wastes may interfere with the use of the stream for the production of food and recreational purposes. Thus a stream utilized extensively for one purpose frequently may not be satisfactory for other uses. Realizing this fact the state of Pennsylvania has divided its streams into three classes: (a) Streams practically unpolluted. (b) Those somewhat polluted and where the extent of regulation or control involves a consideration of the present and probable future use; also practicable remedial measures for abatement of pollution. (c) Streams so polluted that they can be used only for the disposal of sewage and waste and, therefore, the only treatment of wastes required is such as will prevent local nuisances.

It is probable that as our country develops, more complete classifications of streams will be necessary in order to continue our industrial developments and yet retain some of our natural advantages. Any substance entering a stream may, technically, be considered pollution, but from the broader and more practical standpoint only those substances that cause objectional pollution are significant. This interpretation involves not only the character of the wastes but the uses of the stream and the effect that such polution may have upon these uses.

Pollution may be divided into these classes: (1) Sewage or waste carrying dangerous disease germs; (2) organic substances that consume or reduce the oxygen normally present in the water of the stream; (3) material that is actually poisonous or toxic to the aquatic life of the stream; (4) suspended matter that may form in the bottom of the stream and thus interfere with its natural channel or aquatic life.

Domestic sewage constitutes the greatest menace to the public health because of the disease germs that it always carries. The organic substances, however, are material factors in reducing the dissolved oxygen so that a stream may be unable to recover as rapidly from its pollution as it would normally. Furthermore, if the dissolved oxygen is reduced to less than two parts per million for any material length of time, fish will die or seek other habitat and, if entirely depleted, the green aerobic plants

of the stream die and anaerobic organisms prevail thus completely changing the normal character of the stream. Relatively few wastes have a direct poisonous or toxic effect but many of them produce objectionable sludge or deposits. Fibers from pulp and paper mills are probably a material factor in the formation of sludge that interferes with the spawn and spawning of fish, while sulphite liquor from pulp mills has an oxygen consuming power seventy-five to one hundred times as great as that of domestic sewage. In fact, most industrial wastes are greater factors in reducing the oxygen of a stream than ordinary domestic sewage.

In the natural decomposition of wastes, animal or vegetable organic matter is first changed into unstable nitrogenous compounds by the action of certain anaerobic bacteria. This material is then nitrified or oxidized by aerobic organisms to a nitrate form which may be again consumed by the plants and the plants in turn by animals, thus completing the natural cycle. Some such process actually takes place when wastes are discharged into a stream, the organic matter rather rapidly reducing the oxygen content of the water. Gradually, however, the stream will furnish sufficient oxygen through aeration over ripples and falls or oxygen supplied by growing plants in addition to that normally present in the water so that complete nitrification takes place and gradualy the "sick" stream recovers practically its normal condition. Bacterial pollution also gradually disappears, extensive investigations by the U. S. Public Health Service indicating that approximately 90 per cent of the bacteria are removed in about one hundred hours' flow. This reduction is more a factor of time than of distance. If, however, a stream receives additional pollution at several points so that sufficient time does not elapse between, its complete recovery is impossible.

With all of these conflicting factors, one is confronted with a very difficult problem in order that the resources of our streams may be so conserved and yet utilized that the interests of man may be protected and his wants supplied. In other words, the problem in reality involves an economic and practical untilization of our streams that the greatest benefit may be derived for all concerned. It is very probable that certain streams used extensively for waste disposal cannot be utilized for public water supplies or recreational purposes and it may be that in certain instances they cannot even be retained in a satisfactory condition to sustain normal fish life. In many states it is still possible to retain streams in a reasonable state of purity but in large centers of population this is probably impossible and is certainly impractical. A final solution of the problem, therefore, involves a determination of uses of streams of greatest advantage and benefit to man. This will probably make necessary the use of some streams for one purpose that others may be available for other uses.

The question of stream pollution has been a subject of legislation for many years. Early English laws in 1865 provided for sewage disposal but stipulated that "it does not authorize the direct discharge of sewage or drainage into streams." Later legislation tended to prohibit the discharge of sewage and wastes but this was found to be impractical since the only outlet for such wastes was, in many instances, into the water courses. Legislation about 1875 provided for control of construction, operation and maintenance of sewage disposal plants. A more comprehensive law in 1876 known as the River Pollution Prevention Act, however, covers more completely the discharge and disposal of sewage of industrial wastes stipulating that "it shall not be considered a violation if the best practical and available means of rendering harmless the sewage is used." It further provides that in considering application of law the government "shall have regard to the industrial interests involved."

Probably the earliest comprehensive legislation on stream pollution in America was in Massachusetts where in 1872 legislation was enacted requiring the State Board of Health to investigate the subject of sewerage, including sewage disposal and stream pollution. There followed an investigation of and report upon the condition of streams and in 1866 legislation was enacted requiring the city of Worcester to treat its sewage. In 1888 comprehensive experiments were started under the direction of the State Board of Health at Lawrence. These experiments are still being continued and have furnished the basis for practically all modern methods of sewage treatment and, in fact, they constituted the first comprehensive scientific work done. From this time the development in the

process of sewage treatment has been rapid, probably due largely to the definite establishment of the relationship between such pollution and water-borne diseases.

The question of the treatment of industrial wastes, however, has not kept pace with that of the treatment of domestic sewage. In fact, the problem of industrial waste disposal has been little considered until in recent years.

A careful study of judicial decisions as chronicled in Public Health Bulletin No. 67, on stream pollution by S. D. Montgomery and Prof. Earl B. Phelps and published by the United States Public Health Society, together with other available data, may be briefly summarized as follows:

(1) Each riparian owner has a dual interest in the stream and is entitled to have it flow through or past his lands unimpaired in quality or quantity except for reasonable use by owners above.

(2) Natural use as for domestic purposes or watering cattle has generally been favored by the courts over artificial or use by industries, discharging of waste by industries being considered unnatural use of the stream. Excessive or immoderate use even for natural purposes, becomes unreasonable and illegal.

(3) Public benefit or the fact that a riparian owner can protect himself at reasonable cost does not reduce this liability.

(4) Municipalities have no greater rights than individuals in polluting streams.

(5) Surface drainage is not ground for complaint unless controlled or increased by water from another source so as to exceed the natural capacity of the stream.

(6) Some courts have held that customs of the region are relevant, others that they are not. Excessive pollution for a prescribed period may establish the right to continue pollution.

(7) In any instance such pollution as will create a public nuisance can be enjoined.

(8) Prescription may be acquired to pollute a stream provided a public nuisance is not created and the procedure is not contrary to state laws.

Because of local regulations and conditions, the enforcement of legislation in regard to stream pollution varies somewhat in different states. The following points in this respect may be noted:

(1) A state may, without compensation, curtail the rights of riparian owners to the use of a stream, such legislation being valid even if applicable to only a part of the state provided no unreasonable or arbitrary classification is adopted.

(2) Some courts have construed the statutes liberally in favor of the riparian owners. This has been generally the policy in Wisconsin. Pennsylvania and Indiana courts, however, have generally permitted certain pollution as from mine drainage notwithstanding the fact that this practice has been repudiated in other courts.

(3) A state may leave to a commission or board the details of legislation for protection of its waters but may not authorize the discharge of sewage or waste into streams to the injury of riparian owners, since this is limited by constitutional provisions.

It is evident from the above that the courts generally concede that a certain amount of pollution is permissible providing no definite or material damage is done to riparian owners. The extent of this permissible pollution, however, is dependent largely upon the use made of the stream, local conditions and customs. What might be objectionable pollution in one instance may be immaterial in another and vice versa.

Based upon questionnaires sent to the various state boards of health in regard to their facilities for the control of stream pollution to which forty-two replies were received, the following information is presented:

(1) In twenty-two states the control of stream pollution is vested in the state board of health only, in nine in the conservation commission and state board of health and in two in these two and one other body. In one state the conservation commission only has jurisdiction, in three, special boards have been appointed, and in six no organization has definite jurisdiction.

(2) In twenty-three states the board of health may require treatment of sewage or industrial waste, in four, this can be accomplished only through nuisance laws, and in fifteen, such control is difficult.

(3) In one state, plans for treatment of wastes are prepared for small installations by the state board of health and in fifteen, plans are outlined or types of treatment suggested. In twelve states, approval of plans only is provided for

and in fourteen, the whole question of treatment of the wastes is left to the owner.

(4) Only seven of the forty-two states conduct research on the problem of waste disposal or stream pollution.

(5) In six states, the state boards of health investigate conditions when fish life only is affected, in four, this board cooperates with the conservation commission, and in thirty-two, it takes no part where fish life is affected.

(6) Eighteen states reported that the present arrangement is satisfactory and twenty-four that it is not.

These results bring out: First, that authority is divided in most of the states; second, that the control is indefinite; third, methods of control and assistance for industry are indefinite; fourth, that no research is being done toward a constructive solution of the problem; fifth, that the question of fish life is not being considered by state boards of health although the type of control is very analogus to that necessary to protect the health; and sixth, that although conditions are reported to be satisfactory in eighteen of the states it is probable that these replies referred specifically to control where the public health is affected.

In the problem of indutsrial waste disposal one must consider not a single problem but a series of problems more numerous than the different classes of industries. Methods applicable to the disposal of sanitary sewage frequently cannot be adopted to waste disposal, and, if practicable, changes or modifications are necessary. In many instances, however, entirely different methods are required involving very intimate knowledge of the industry itself in order that recovery processes for the utilization of by-products may be developed. A method applicable to the waste from one plant of any industry may not apply to another. For instance, in the canning industry the problem of disposing of wastes from a pea canning plant is entirely different from that of a sauerkraut factory. Likewise in the chemical industry, the problems of the different plants vary materially.

The most recent and probably the most satisfactory development and tendency in the control of stream pollution is the establishment of boards or bodies in whose hands is placed the whole problem of stream pollution, including both the disposal of sewage and industrial waste and their effect either upon the public health or the aquatic life of the stream.

A step toward the consolidation of this line of work in Wisconsin was taken by the last legislature by appropriating $10,000 from the conservation fund to be used in the control of stream pollution and to be expended in cooperation with the state board of health in a manner agreed upon by the conservation commissioner and the state health officer. The state of Ohio has also inaugurated a constructive program in the control of stream pollution and other states are rapidly taking up the problem. In Pennsylvania, committees representing the tannery and paper industries have been developed to cooperate with the Sanitary Water Board in their problems. In Wisconsin a similar committee has been created representing the paper industry and cooperation from the Pea Packers Association has been secured. In Ohio conferences have been held with numerous of the industries and similar committees are being developed. The tanneries of Pennsylvania have combined and voluntarily assessed themselves $35,000 to conduct research work. In Wisconsin the Pea Packers Association, at the request of the State Board of Health, assessed themselves $500 to assist in certain research during the coming summer regarding the disposal of their wastes.

Probably the most comprehensive national program inaugurated, however, is that in connection with the paper industry. In December, 1925, a conference was held between a representative of Wisconsin State Board of Health and the Pennsylvania Water Board with certain of the paper interests at which was inaugurated a movement to develop a national program for investigation of the unsolved problems in the disposal of wastes from the pulp and paper industry. This movement was supported by the paper interests of Wisconsin and Pennsylvania and was heartily endorsed by the sanitary engineers of practically all states where the disposal of pulp and paper mill wastes is a problem. At the annual meeting of the paper industry at New York City during the week of February 22, a formal resolution was adopted:

(1) That the necessary organization be set up with the power to coordinate existing efforts to find a solution to the problem of disposing of pulp and paper mill wastes, to inaugurate and prosecute a crystallized, comprehensive investigation of the problem and to devise ways

and means of financing the investigation.

(2) That the expense of such investigations be borne by the industry with such assistance as may be obtained from the federal government and interested states.

(3) That in the conduct of investigations the organization secure the cooperation of the Forest Products Laboratory or other qualified government agencies.

(4) That an administrative committee of the pulp and paper industry be created to accumulate and distribute available data and to direct the cooperative work undertaken, this committee to cooperate with a national advisory board of representatives of the national organizations of the paper industry, state representatives of the industry, and the chief sanitary engineer or similar official of each interested state.

(5) That it is the intention of this resolution that each interested state shall have complete control of all matters within its own jurisdiction.

It would seem that if similar organizations were developed with other industries, their problems could be handled in a national way with less expense to the industry and with better results. The work involved in such an investigation, however, is practically only that of a technical nature in the development of proper methods of waste disposal or of recovery processes that will eliminate objectionable wastes. The application of these methods of treatment is primarily a local problem for administration in each individual state since the application depends to such a great extent upon local conditions such as uses to be made of a stream, etc., as has been previously pointed out.

Another important development consists of compacts or agreements between states for the control of pollution interstate in character. Such agreements include those between Pennsylvania, New Jersey, and New York; between Pennsylvania, Ohio, and West Virginia; and between Pennsylvania and New York. The state of Wisconsin is now cooperating with Minnesota by contributing to a survey of the upper Mississippi River under the direction of the United States Public Health Service.

With this multiplicity of problems and indefinite data available, it is impossible to set up definite rules and regulations controlling the problem of waste disposal and stream pollution. It is believed, therefore, that a constructive program should include the following:

(1) Centralization of administrative authority in one head or board.

(2) Provision that this board may enact rules and regulations having the force and effect of law.

(3) Legislation requiring that permits be secured from the board by any industry, municipality or owner, to discharge wastes into any stream.

(4) Provision that the board may require such treatment of wastes as may be practicable and necessary to minimize the effect of their pollution.

(5) Definite control over the operation and maintenance of sewage or waste treatment plants.

(6) A careful study or survey of streams to determine first the effect of pollution and second, whether treatment processes installed are accomplishing the work expected of them.

(7) Chemical, bacteriological, and biological surveys of the streams to determine the effect of wastes upon their flora and fauna.

(8) Experimental work in the various problems of waste disposal either individually or in cooperation with the various industries.

(9) Correlation of this work with the control of stream flow, such as the construction of dams, impounding reservoirs, etc.

(10) Finally, close cooperation on the part of the board with industries, other states, the federal government, and others interested in the problem.

ASPHALT SPECIFICATIONS—OPEN VS. CLOSED

By Gene Abson, Chicago Paving Laboratory, Inc., 536 Lake Shore Drive, Chicago, Ill.

In the course of our consulting practice we are often confronted with the question, "Is 'native lake' or 'natural' asphalt better than 'petroleum' or 'oil' asphalt?" Invariably our answer has been in the negative—and invariably the next question is "Why?" It will be the purpose of this paper to answer the questions at length.

Although general usage has more or less classified asphalt into two groups, the so-called "native lake" and "petroleum," there is really no such distinction. Paradoxical as it may sound, all asphalt used in paving work is both

'natural" and "petroleum" at the same time: "natural" because it is not made synthetically, and "petroleum" because all authorities are agreed upon the point that asphalt is a metamorphosed product of crude mineral oil, which is to say, derived from petroleum. Furthermore, all "natural" asphalt which is in use occurs in a solid rather than a liquid state and after a refining process (variable with different "native" asphalts) must be fluxed (that is, softened) with a heavy petroleum distillate or residue, in varying quantities. The final product which is used in paving work is, therefore, a mixture of "natural" and "petroleum" products and, technically speaking, is just as much a "petroleum" as a "natural" product. However, since custom has arbitrarily differentiated between the two classes, the same references will be used in this discussion and the various asphalts will be classed according to source, rather than derivation.

The alleged superiority of "natural lake asphalt" over all other products is based upon several contentions, of which the most quoted is that it is produced by nature. This carries with it the innuendo that Nature always bears in mind the uses to which man adapts her products, and by supernatural power fabricates materials which man cannot even approach in quality. Were this ever true no arguments could be advanced, but since it can be shown that the handiwork of Nature is more imperfect than that of man, this statement per se carries no authority nor argument.

One need only to glance back over the last quarter century to see that man has devised and discovered processes and products of which nature never dreamed. As Dr. Slossom has so admirably pointed out in his "Creative Chemistry," the ability of man to create shades and colors and brilliance in artificial dyes which never occur in nature has proven the ability of man to surpass natural processes. And countless products once thought to be divinely created are now produced synthetically—and most astonishing of all—with greater purity, wider adaptability and cheaper than Nature ever could; such products as rayon (man-made silk), methanol (synthetic wood alcohol) which is threatening to put the wood distillation people out of business, bakelite (synthetic resin), etc., are outstanding examples. And it would seem that synthetics need not compete under false colors; witness: Karo, Mazola, etc., which clearly indicate their source, and without stigma in the mind of the housewife.

The imperfections of nature are ever present—and this must not be taken as derogatory. The degree of perfection or imperfection of anything is simply a comparative measure of man's preferences in his processes of adaptation. A seedless orange is a more perfect product from the viewpoint of the average American at his breakfast table, yet Nature's oranges contain the seeds and only man's ingenuity succeeded in improving upon the natural product to this extent. We have no other way of judging superiority. Perhaps to the Deity who created the universe, a seedless orange is highly imperfect—useless since it cannot propogate its kind, but until some future day of enlightenment we are perforce restricted to the judgment of "homo sapiens."

Another reason for the alleged superiority of "natural" over "petroleum" asphalt is that it has been in use for a greater number of years. Quite true, and still unconvincing! When "petroleum" asphalts have been eminently successful in the construction of pavements for thirty years and upwards, who would be right in stating that they are still of unproven merit? It seems to require a special manipulation of one's sense of reasonableness and distortion of perspective to look back over so long a period and still be unconvinced. One might draw an analogy with the philosophers in the time of Gallileo. This distinguished scientist demonstrated that two balls, one weighing one hundred times as much as the other, when dropped together from the top of the leaning Tower of Pisa, struck the ground below at the same instant. His elders, whose philosophy taught them that the one hundred unit ball would fall one hundred times as fast, severely reprimanded him for trying to disturb the serenity of their minds and warned him against further demonstration.

This question of superiority might further be shown to be fallacious when it is known that the 5% to 10% (more or less) of asphalt which comprises a modern pavement is *not* the most important constituent; 90% or more of an asphalt pavement is composed of mineral grains of various mesh sizes, the proper proportioning of which is tantamount in

importance. If the asphalt alone were the sole important factor, why should it be necessary to search for special sands, ship filler long distances and make elaborate provisions for heating, mixing, transporting, laying, finishing, etc.? Contrary to some opinions, the asphalt undergoes no chemical change, no setting or other reaction whatsoever, except the physical change of cooling and becoming a plastic binding medium.

This, however, must not be taken so literally as to assume that anything sold under the name of "asphalt" would be useful. It simply means that, with the knowledge gained in years of experiment and experience, it is extremely easy to specify the most important physical or chemical tests which will demonstrate the utility of an asphalt for a given purpose. The experience gleaned from intimate knowledge of capable men throughout the country has resulted in the adoption of specifications by such eminent bodies as the A. S. T. M., A. S. M. I., and the Asphalt Association, which draw no distinction whatsoever between the various asphalts produced from various sources. Tests for the identification of derivation or source are no more important than specifying crushed limestone from pre-Cambrian or Silurian ages, yet such seemingly ridiculous procedure is often followed by some.

Assuming another thought in the direction of the duty of the engineering profession toward his clients and constituents, it is almost superfluous to say that an engineer must welcome competitive bidding in the matter of street paving. One of the most effective ways of *eliminating* such a duty is to specify one brand of "natural" asphalt or one brand of "petroleum" asphalt. Invariably, in the writer's experience, has the opening of "closed specifications" resulted in an astonishing reduction in cost, not only for the competing products, but likewise for the identical asphalt which had been previously specified alone.

Another form of deliberate intent to restrict open competition has found itself in the substitution of "alternate specifications" for the "closed specification," or in other words, substitution of *two closed* specifications. While seemingly removed from the stigma of specifying certain materials, this practice is just as vicious in its working as using only one closed specification, because it permits the selection of materials to fall into the hands of a few individuals. Invariably it has been found that costs are increased for *both kinds* of asphalts, and that usually the higher priced material is selected, for reasons that need not be discussed here.

Technical reasons for asserting that one standard specification will insure highly satisfactory asphaltic material are not necessary in this paper; it may be assumed that, since nearly every large city in the United States uses open specifications, some valid reasons for their adoption have been formed.

Therefore, when questions such as stated in the opening paragraph are asked of our organization, we unhesitatingly and inflexibly answer that there is not a penny's worth of difference in value between various standard brands of paving asphalts.

SAFETY PRECAUTIONS IN EXCAVATING WORK

By George Hess, Vice-President, Thomas Haverty Co., Los Angeles, Cal.

(The following paper was read March 17, 1926, before the Fifth Annual Industrial Safety School at Los Angeles, Calif.)

You have just listened to a very interesting and instructive lecture on "Fatigue." I was amazed to learn of the number of accidents that occur between 4:00 and 5:00 o'clock in the afternoon, and it recalled to my mind the four men killed on our sewer work in the past five or six years. The first man lost his life about 4:00 o'clock in the afternoon, two others at 4:30 and the fourth about 4:15 in the afternoon. This gives us something to think about, and the only thing that suggests itself to my mind would be to close the jobs down about 3:00 in the afternoon. Of course this condition would probably be impractical, but if most of the accidents do occur late in the day, then special care should be taken to avoid them.

It is horrifying to me to be walking down the street and see the glaring headlines of the papers blaze forth the news that a cave-in has killed another man. The thought instantly strikes me that it might be one of our own men, and there is nothing that drives safety measures home more forcibly than after a man is severely injured or killed on one of your own jobs.

Accident in Trenches

I remember distinctly the first man who lost his life on one of our ditches.

He was a young Mexican whose duty on the Temple St. sewer was to remove the timbers after the pipe was laid and the back-filling was proceeding. This young fellow had removed the jacks and timbers on several miles of ditch but like many other men before him, grew careless. The proper way, and the way he was instructed to remove these timbers, was to loosen the bottom jacks first. The back-filler would then deposit 3 or 4 ft. of earth in the ditch and the next layer of jacks would then be removed, and so on until the top jacks were removed. This particular ditch was about 20 ft. deep and from appearances the earth was as strong as a brick wall. Therefore, instead of starting from the bottom, he removed the top jacks first and started to work down. The two walls, not being held apart by the timber and jacks, came together at the top—and when we dug him out late one Saturday night we found him standing on the jack below with the jack he had removed in his hand, his skull fractured. He had been instantly killed. If his head had been a few inches lower he probably would have escaped without any injury whatever.

On another job that we had, two laborers were killed in a ditch not more than 5 ft. in depth. This was over on Alameda St., near the Llewellyn Iron Works, and was caused by a group of fibre telephone conduits falling down on the men and crushing them to death. We had a very capable foreman on this job and the conduit supports had been properly inspected by the foreman, but evidently the laborers removed part of them in order to have more space to work. It is very important to watch your men carefully, otherwise they will take unnecessary chances and risk their lives when there is no occasion for it.

Competition in the sewer business is exceptionally keen and most contractors figure that they cannot afford to take proper precautions, therefore they take long chances that are actually criminal, and I would be greatly in favor of more strict laws controlling the timbering of sewer trenches. The Inspection Department of the Industrial Accident Commission has always been ready to assist and advise in matters of this kind. Owing to the tremendous number of jobs in and around Los Angeles it is impossible for inspectors to be present on all jobs at all times, therefore it depends on the contractor, foreman and workmen themselves to use reasonable precautions in shoring and bracing their trenches. The bracing and shoring of trenches should be carried along with the excavation, and where a mechanical digger is used, the shoring should be as close to the wheel or boom as conditions will warrant.

One of our excavation machines will dig a ditch 26 ft. in depth and one will dig 32 ft. in depth. Just think of a straight wall 32 ft. high—think of the tremendous weight that has to be held back by timbers and jacks. Remember that there is a tremendous pressure exerted on the walls of this ditch due to the fact that most of the dirt has been deposited under pressure and is only waiting for a chance to expand or swell. Then think of the tremendous weight of the spoil-bank—all of this excavation material from the ditch is usually deposited on one side of the ditch. Think of the vibration caused by heavy trucks delivering your sand, gravel, and cement, often traveling within a few feet of your trench—then you can begin to realize, if you haven't considered it before, just the natural conditions causing cave-ins—ordinary earth has a slight binding effect—the tensile strength however is small. However, if you provide shoring and bracing immediately upon opening a ditch you can take advantage of the slight suction or tensile strength of the soil, but if the banks begin to break and crack, it requires a tremendous amount of timber to keep it from sliding. The idea is to provide enough timber to prevent it starting, as after it starts it takes a terrific power to hold it back.

Shoring Methods

We have found that the most satisfactory method of shoring sewer ditches is by the use of 3x12's placed vertically in the ditch. It is best to place these 3x12's so their bottoms rest on a firm foundation at the bottom, so that friction between the planks and earth will help support the wall. Earth of course begins to crush under a certain weight the same as granite, brick or any other material. Instead of using wood spreaders, we have been using regular sewer jacks with pipe extensions and large cast iron flanges, so that the foot of the jack and the flange would have plenty of bearing surface. We like this method best, because you can exert a great deal of power on account of the screw feature of the jack and it eliminates the jarring and vibration ordinarily required in driving wooden bracing into place.

Be sure to place your jacks at right

angles with your timbers, and as near level as possible because if they are placed at an angle their usefulness is more or less destroyed.

In lowering tools or materials to the men working at the bottom of the ditch, it is better to use rope with a small hook attached, and lower the tools or material into place rather than to drop them, for the reason that obstructions in the ditch may cause deflection if the tools are dropped down, thereby injuring the men working below.

Ladders in a ditch are also an important item. In case the ditch should begin to cave in, men can hurry to safety by the use of a ladder. Have plenty of these ladders located at convenient intervals along the ditch.

We have also made it a policy to have plenty of planks spread across the ditch to save the danger of men standing directly on the edge and then having the edge give way due to a leaky water pipe or sand pocket in the surface.

Be very careful and watch that the men do not work in the ditch if intoxicated, as they are not only liable to injure themselves but do serious injury to the sober men. On the Outfall sewer we had a young chap who complained of being dizzy after a hard night, so our superintendent sent him home. After he got home he went to the window, and leaning out—fell to the concrete pavement below and broke his neck. For two years he laid on his back, but finally passed away a couple of months ago.

Trenching With Mechanical Diggers

In digging trenches with mechanical diggers be very careful of your operators and men working too close to the boom. The operator should always be on the lookout and never start his digging machine until he is absolutely certain that the men are clear of the teeth and chain. On one of our sewer jobs, one of our workmen slipped and fell on the revolving chain, but the operator, watching conditions, had the chain stopped before the man actually hit the boom. This man would have been ground to death if the operator had not been on the alert.

Just recently one of our men narrowly escaped serious injury because the operator started the digging machine before the man working on the boom got clear of it. This was due to extreme carelessness on the part of the operator, because on this particular digging machine we had the operator's platform so built that he would always be in sight of the men around the boom.

Not only is it more humane to be careful, with safety measures, but it is more profitable. It is much cheaper to brace a ditch to prevent a cave-in than it is to clean out a ditch after the cave-in occurs, even though no one is hurt. But, it is the great danger of injuring or killing the men that should warn you to play safe.

Why Cave-ins Are Dangerous

The next time you go down to the beach, let someone pile about a foot of sand over your body—then you will begin to realize what an enormous weight the body had to support, even though a man is only buried with a yard or two of dirt.

On the Outfall sewer we had a young fellow crushed between the bank and the completed sewer. The dirt rolled down a sloping bank and pinned him against the pipe. He was only slightly covered above the hips but the weight of the dirt broke his pelvis bone and death occurred almost instantly. When I visited this sight I could scarely comprehend how such a small amount of dirt could kill a man, and many of you here who have never had a serious accident on your jobs, fail to realize how a series of accidents can occur even though you have been lucky in years gone by.

In digging for the Outfall sewer, it was necessary to excavate through peat beds, which we did by means of drag lines. I have stood on the banks and watched the peat and earth come up from the bottom at the rate of 5 ft. per minute. This was caused by the weight of the spoil-banks in nearly every instance.

Danger in Paralleling Pipe Lines

The contractor who had one of the sections of the Outfall sewer had a ditch open for 500 or 600 ft. The old temporary Outfall sewer paralleled this ditch. Leaky joints in the old sewer caused the banks to give way and one whole side of the ditch caved in. This ditch was about 40 ft. wide at the top and 20 ft. deep at the time of the accident—so be very careful when you parallel pipe lines.

If the sewer trench parallels water and gas pipe or another sewer, or possibly a concrete curb, special care should be taken that same does not break loose and fall into the ditch, thereby hurting the men working below. Do not dig too close to telephone or telegraph poles un-

less you take proper precautions to prevent them breaking loose from their bearings.

I noticed a job over near the river, where the sewer contractor was excavating by means of a drag line, and deposited his dirt on a small train of dump cars hauled by a gasoline locomotive. It was a miracle to me that those banks did not give way as the train ran up and down the edge of a very sandy ditch with the banks sloped at a dangerous angle.

Precautions With Mechanical Excavators

When excavating with drag lines be very careful and keep the boom and cables away from overhead power wires. It is best to cover the booth with woodlagging if there is any danger of striking the power wires. It is very dangerous to dump a drag line bucket directly into a dump truck or small car if the driver is sitting on the truck, as an operator cannot control a drag line bucket quite as effectively as a steam shovel operator can his dipper.

When digging with a mechanical digger, be very careful at night to put plenty of red lanterns around the machine if by chance the machine is on public property. It is best to have two or three lanterns for the reason that if one goes out the others will continues to burn. Remember the law requires you to be responsible for the lights burning and you have no excuse if they don't.

The conveyor on the side of a digging machine is generally a dangerous thing, because sometimes a driver of an automobile will have the top of his machine taken off by striking one of these conveyors. We had a case of this kind at Inglewood a short time ago. The two occupants of the automobile were nearly killed as a result of the accident.

In hauling pipe at night, if you are doing oil pipe line or gas pipe line work, be sure to put a red lantern on the end of the pipe hanging over the end of the truck. You remember the young chap I told you about who broke his back. His sister-in-law was killed in Mint Canyon, due to the fact that the car in which she was riding ran into a truck in which a length of pipe, protruding over the rear end of the truck, came crashing through the windshield and killed her.

On wet jobs it is necessary to have more or less pumps to keep the water level down. The majority of these small diaphragm pumps are gear driven, and in order to facilitate repairs it is customary for the pump men to remove these guards. On the Newport sewer we had a pump man lose the fingers of his right hand by being caught in the pump gears.

Electricity and Gas

In tunnel work as required for some of the down-town sewers, it is necessary to use electric lights, and I have noticed that the men are very careless when touching light wires. Remember that it is very easy to be killed by single phase current if you are standing in wet ground at the time you touch a live wire. A man reaching in the dark to fit a light bulb is liable to cause a contact and be severely burned or killed. There was a man killed on the sewer job on Sixth Street between Grand Ave. and Figueroa, in a sewer tunnel, from this cause.

Another source of danger is the gas that collects in a sewer. In making connection to an existing line this fact is overlooked. Remember that the city sewers are well ventilated through the plumbing systems in the houses, but in a new system before the house connections are made, the main line sewers are unvented.

During the construction of the Temple St. sewer we had quite an explosion on one of our lines, which blew off the top of a manhole. Evidently a leak in a gas main adjacent to the sewer or manhole permitted illuminating gas to enter the sewer and a spark caused the explosion.

Another source of danger is manholes collapsing in backfilling. Be careful to place dirt all around the manhole because if it is piled on one side only it is liable to push the manhole over.

If you are puddling and have the ditch full of water, a collapsed manhole is liable to drown or kill the men working on the inside of the sewer.

When cutting cast iron water pipes, be careful of the man holding the cutting hatchet. At Arcadia balloon field, one of our men lost an eye because a chip flew into it. The man holding the hatchet should wear goggles or protect his eyes by putting his hand over them at the instant of contact between hammers.

Blasting

You may be called upon to do blasting. Dynamite and powder should be handled by experienced men only. Too many of your men will tell you they are experienced in handling dynamite when they actually know very little about it.

We have been very careful when doing blasting, and only use men we are con-

fident know how to use it right. We had an Irishman working for us named Ed. Stevens, who used to take delight in charging his blasts so heavily that we were continually paying damages for broken windows two and three blocks away from the scene of blast. I have seen rock hurled by his blasts through the air for two or three hundred feet. This was carelessness. Later on Mr. Stevens committed suicide by blowing out his brains, so probably that was a reason for being careless with dynamite.

Use of Trench Helmets

In digging ditches through gravel formations, it often happens that boulders will break loose from the side walls and drop on the men below. We have a supply of steel trench helmets that we request the men to wear in ditches where this danger is liable to occur. It doesn't take so very much to fracture a man's skull.

Some of the tunnels under the downtown streets are very poorly timbered. I have often wondered why we haven't had more serious accidents than actually have occurred. Even though you provide your men with timbers, nails, saws, hatchets, and all necessary tools, they are very apt to take long chances, and the duty rests with the foreman and superintendents to guard against extreme carelessness on the part of the men.

I cannot recall a serious accident in any ditch where conditions were really bad. We have been in mud, quick-sand, peat, rock, and clay, but our men realizing that it was dangerous took extra precautions. But our greatest number of accidents have been in ground that looked safe, and they "Took a chance."

"Safety Suggestions

Be careful to barricade your open trenches and keep plenty of red lanterns out at night. A man should be detailed to look after the lanterns on Sunday nights. On jobs of consequence we always keep a watchman for this purpose.

Blood poisoning is a simple process. One of our men scratched his neck with a piece of loose wire hanging down from an overhead obstruction, and in four days he contracted a severe case blood poisoning. Another man wore a bliseter on his hand, it broke, filled with dirt or cement, and he nearly lost his arm because of blood poisoning. Barricades around your ditch will often prevent your men being struck by passing automobiles. We had a laborer suffer a broken leg due to being struck by an automobile which came too close to the ditch.

Remember—that carrying insurance on your men does not prevent loss in actual money, it merely distributes it. Make "safety" your responsibility, and if your men realize that the head of the concern, and the foreman and superintendents are interested in safety measures, they too will be more careful.

Impress upon your men the importance of being careful. Don't permit them to take chances while working for you because if they miss—it is you who have to pay the bill, either directly or indirectly through increase in your insurance premium.

If you are compelled to work at night, provide plenty of light around and in your ditches and on your equipment. During the construction of the Outfall sewer we used nothing but electric power. We had our machines lit up with electric lights and we strung electric lights along our ditches. Not only does it promote greater efficiency, but it does prevent accidents.

Keep plenty of First Aid kits on the work and whenever a man is cut or bruised, no matter how slightly, give him first aid treatment. The foreman or timekeeper can be taught to do this without much trouble.

ECONOMIES OF PRESENT DAY TRANSPORTATION

Celebration by various railroads of their 100th anniversaries invites attention to the economic and social progress which railroad service has helped to make possible during those 100 years, Howard Elliott, Chairman, Northern Pacific Railway Company, said at the annual industrial conference of Pennsylvania State College held on May 14.

"The great service by the railroads," said Mr. Elliott, "was not alone to bridge time and distance; a still greater service was to furnish the means of originating power and raw material in great quantities, using only a small part of the man power of the country, thus leaving the balance of the people free to use power of men, steam and water, to turn raw materials into new products.

"Prior to the Revolution, land transportation in the country was furnished largely by men or animals, while today there are being handled by less than 2,000,000 men more than 400 billion ton-miles of freight each year. The

physical effort to do this represents the labor of about a billion and a quarter men; and the cost to the public has decreased from about $3 to 1.1 cents per ton per mile. Of course, it would be impossible to supply this amount of man power, but the comparison is given to show how the efficiency of the railroads has released untold man power for work in other directions. This great saving of man power and the great development of other forms of power permit almost two-thirds of the population to be sustained without any direct contact with the soil.

Dependence Upon Adequate Transportation

"This condition has also permitted the building of our wonderful cities with their highly divided forms of specialized labor, still further increasing man's productive power, and improving the living conditions in many directions. So obvious is this dependence upon adequate transportation that the railroad system of a modern country determines the extent to which highly specialized subdivisions of man power and great production at a maximum economy can be obtained.

"Those methods of transportation which require a large amount of man power for the output of a small volume of transportation cannot compete with the railroads in the major work of maintaining a nation like the United States on its present high plane of industry and social life.

"Those alternate forms of transportation have a field of usefulness in giving supplemental service to the primary system. These supplemental forms are helpful to modern civilization as aids to health, comfort and pleasure, but the amount of transportation needed by industry that they can produce per man employed is, except in the case of water, much less than on the railroad, and to that extent they are less economical for society as a whole. It is a debatable question today whether there is not too much labor and capital being diverted to these forms, and away from other work equally essential to the progress of the nation.

"The great public utilities of our cities and the great machine industries today carry on the process started by the railroads in the mass production of power and raw material. The United States is the premier country for volume production carried in with high wages, but at low unit costs. This is based upon the mass transportation service of the railroads. They carry about ten times as much business per inhabitant as do the railroads of Europe and three times as much per person as was required in this country only twenty years ago,

Railroads Won By Economic Merit

"This fundamental position in the economic structure of the country was won by economic merit. I stress this point because it is important in considering all related transportation agencies and has a vital bearing upon all alternative or supplemental means of transport.

"Modern railroad development in this country can be said to have started about 1880, when the population of the country was about 50,000,000 and its economic activity was represented by 32 billion ton-miles of freight transportation. In 1925 the country had a population of 115,000,000 and its activities were represented by 416 billion ton-miles of freight transportation.

"In these forty-five years the railroads increased their freight service thirteen times. But in doing this they multiplied their investment only five times; they more than cut their level of freight rates in two; and in spite of the increase in present costs over those of half a century ago, they furnish passenger service in quantity and quality undreamed of at prices very little more than those fifty years ago.

How to Cheapen Railway Transportation

"The idea so prevalent in the past that the way to cheapen railway transportation is to increase the volume of business to be handled by the great mass producer of transportation—the railroad—because it has shown a constant ability to use increased volume to diminish unit costs except where prices of labor and materials were beyond its control. And even then improved appliances and practices have prevented costs from rising to the same extent that prices of material and labor have risen.

"Modern economic society is built upon the foundations supplied by the railroads and society will help itself best by giving to them all the business which economically belongs to them and allowing this great servant of all the people a 'living wage.'

"The next twenty-five years of industrial and economic development will, I believe, bring an increasing amount of

cooperation and confidence in our national economic life, and a gradual elimination of suspicion, irritation and conflict between the public, labor and capital. To live in those years, to serve the government, to teach, to do business, to run a railroad, will be a deeply satisfying form of service to society."

SANITARY CONSERVATION OF STREAMS

(Editor's Note: Following is the full text of the progress report to the Conference of State Sanitary Engineers by the Committee on "Sanitary Conservation of Streams." Mr. Arthur P. Miller, Washington, D. C., is Secretary-Treasurer of the Conference of State Sanitary Engineers.)

Scope

Water resources belong to the public. Property owners or those given allotment have a right of use. Anything which is owned in common by many is generally abused by some. To prevent such abuse and improper use, conservation measures are being adopted for many natural resources. Conservation does not mean hoarding but it does mean the adoption of measures to make that which is conserved increasingly useful. As applied to water resources discussed herein "Sanitary Conservation of Streams" includes means to promote the health, welfare, comfort and prosperity of the people of the State through control of sewerage and the disposal of sewage and industrial wastes so as to attain the prudent and wise utilization of the water resources.

The Problem

Streams form the natural drainage channels of the land and hence of necessity must receive the sewage of towns and the liquid wastes from industry and the development of natural resources. To the town, the industry or the mine, the easiest and cheapest way of disposing of wastes is obviously by direct discharge to the nearest water course which carries it away. But in so doing, down-stream users or riparian owners may be harmed. Hence there must be State control over what is discharged to the streams so they can serve the higest public interests.

The problem confronting the legislative and executive departments of the State governments, is to provide and enforce statutes which will prevent undue and harmful pollution of the water resources and provide for reasonable and proper uses of streams.

Conservation

Water is an absolute essential to life; and pure, wholesome water to the health of man. Every successful plan for the sanitary conservation of water resources must be predicted upon principles which will surely provide amply and satisfactory sources for public water supplies not only of the present but in the future. This means, in most states which are reasonably developed, that strenuous efforts must be made to preserve the cleanliness of streams now in that wholesome condition.

Experience has demonstrated beyond the shadow of a doubt that, to a certain extent, streams can inoffensively assimilate polluting matter in limited and variable amounts depending upon the composition of the wastes and upon the characteristics and subsequent use of stream.

Sanitary conservation, therefore, does not mean the treatment of all polluting matter to a high degree but rather a determination of the pollution load which each stream or part thereof can inoffensively and harmlessly assimilate, if any, and then a utilization of the stream to that extent and a requirement for the treatment of all excess pollution load to such a degree as to maintain the stream in a condition fit and suitable for its highest uses.

In isolated instances cases arise where the most useful present function of a certain stream is the conveyance of untreated industrial wastes and where it may be found necessary or advisable to use such streams for this purpose.

The regulation of the rate of stream flow by creation of reservoirs to hold back flood waters and provide for release of the stored water during periods of otherwise low stream flows has a direct effect upon the sanitary condition of the streams below the reservoirs through increasing the diluting water available for assimilation of the polluting matters discharged therein.

Utilization

Any plan or project for the sanitary conservation of water resources to be practical and successful must recognize the dominant use of the streams either in the State as a whole or in its various parts. For example, in an agricultural state where streams are extensively used for watering stock and industry is negligible, obviously the main-

tenance of streams in a very cleanly state best serves the public interests.

On the other hand there are parts of some states drained by rivers not used as source of public or industrial water supplies and having valuable and important industries on their banks—and where it now appears that the prosperity of these industries justifies utilizing the river primarily for disposal of industrial waste provided that harm be not done to any other interest equally valuable to the State as the aforesaid industry upon the banks of the river. Property damage suffered by riparian owners is a matter to be considered by a court of equity rather than by an administrative agent of the State.

The trend of today is more and more toward an out-door life. The automobile and improved highways carry the city dweller far away from home into the country, the forests and the mountains. Outdoor swimming pools, the family picnic on the bank of a stream, hunting and most of all fishing are building up in the minds of many people the idea that all streams can and should be restored to their pristine purity.

But there are other interests which must be considered. The legislator and the executive must bear in mind the financial aspect of the problem and adopt policies which at minimum expenditure of public and private funds will bring about a condition of the streams whereby all interests will be wisely served but in the order of their value to the public.

This leads to a determination of the order of precedent of use of water resources.

There can be no question that the use of water resources as the source of public water supplies is the first and highest use.

As streams are the natural drainage channels of the land it follows that the second highest use from a sanitary standpoint is for the conveyance of sewage of municipalities, industrial wastes from existing establishments and liquid waste or water carried solid wastes resulting from the development of natural resources, all obviously treated, if needful and possible, to such a degree as required to maintain the receiving body of water in a condition fit and suitable for its highest use.

Therefore, the order of precedence of use is determined by local circumstances and may be for navigation, manufacturing, industry, power, irrigation agriculture, fishing or recreation.

Ideal Statutes—To Prevent Initial and Increasing Pollution

(a) Requiring issuance of State permits for approval of plans of all proposed sewerage projects and for the discharge of sewage or treated effluent and stipulating such modification, conditions and regulations as protection and promotion of the public health and welfare may require.

(b) The same as to industrial wastes.

To Correct Existing Pollution

(a) Empowering proper state authorities to require by police power order the installation and operation of improvements in sewerage works and works for the treatment of sewage, and industrial wastes.

Note: In States where the limit of municipal borrowing capacity is fixed by statute it is possible by suitable words in the ideal statute for such police power order to exceed the otherwise maximum borrowing capacity. Elsewise the Department of Health can pray for injunction to estop the exhaustion of borrowing capacity through expenditures for less needed public works.

To Secure Proper Operation of Works

Empowering proper state authorities to supervise generally the operation of sewage and industrial waste treatment works.

To Adopt a Comprehensive Plan

Empowering proper state authorities to adopt and enforce regulations relative to control of stream pollutions applying to drainage areas, streams or parts thereof so as to provide equitable and effective control under a comprehensive plan recognizing the peculiar use and value of the said drainage area, stream or part thereof.

To Find Solutions of Unsolved Problems in Industrial Waste Disposal

Empowering proper state authorities to conduct research and investigations either alone or in co-operation with industry.

Ideal Administration

Examination of plans and reports on projects, field investigations, reports and recommendations thereon should be in charge of an adequate and properly equipped Bureau of Engineering.

Executive judgment and authority should be vested in the State Department of Health or in a suitable Board or Commission composed of representatives of the various interests concerned

in the conservation and utilization of the water resources.

As the highest use of streams is for public water supply, the head of the State Health Department should in all cases be a member of such Board or Commission and it appears wise for the Attorney General also to be a member in order to participate in all legal phases.

Cooperation

With Municipalities:

The insistent demand of the citizens of a municipality for expenditure of public funds upon improvements from which they derive a direct benefit oft-times causes defeat of large bond issues for sewerage works.

Cooperation between the State and municipal authorities makes possible agreement upon a definite practicable financial program for the progressive construction of sewerage projects within annual expenditures which will receive favorable vote of electors.

With Industry:

In any given industry there are many problems of waste disposal which are common to most of the individual establishments. Such problems can be solved most quickly and economically by cooperative action which should be inaugurated by the State officers calling the representatives of the particular industry in conference to outline the problem and propose the procedure for cooperative investigations.

Between States for inter-state streams:

The abatement of pollution of an inter-state stream in one State which harms the users of the stream in another State can be accomplished through a suit in the Supreme Court of the United States—a tedious, costly and unpleasant procedure.

These difficulties can, in most instances, be overcome by the execution of a compact, approved by the legislatures of the contracting states and the Congress.

Another and simpler method is the execution of an agreement by the authorities of each State having jurisdiction over stream pollutions whereby they obligate themselves to consider the inter-state stream as a whole without reference to the State line.

In the case of an inter-state stream forming the boundary between two states such compact or agreement may set up specific degrees of treatment of sewage and industrial waste for the different parts of the river.

Between States and the Federal Government:

The U. S. Public Health Service has investigatory powers but lacks police power relative to abatement of stream pollutions.

The U. S. Army Engineers exercise authority and jurisdiction over matters affecting navigation of streams. Occasions arise when it is advantageous and desirable to secure the cooperation of the agencies of the State and Federal Government on inter-state stream conservation problems.

Conclusion

Your Committee respectfully submits the above progress report with the knowledge that there is wide variation in the existing statutes, the dominant interests, the physical conditions in the various states.

We, therefore, request the fullest constructive criticism by the conference in the hopes that thereby at the next conference the committee can submit a final report setting forth essential policies which will meet the needs and conditions of the various states and hence can be adopted by the conference for the guidance and help of all the State Sanitary Engineers.

(The report is signed by: C. M. Baker, E. Boyce, W. H. Dittoe, V. M. Ehlers, J. K. Hoskins, A. H. Wieters, and W. L. Stevenson, Chairman.)

HIGHWAY RIGHT OF WAY MAINTENANCE

By O. S. Hess, Managing Engineer, Road Commission, Kent County, Mich.

(Paper read at 12th annual conference on Highway Enginering at the University of Michigan, Ann Arbor.)

For the purposes of this subject let us consider that maintenance of right of way covers all of the work incidental to the proper maintenance of Michigan highways, except the work of snow removal and other activities necessary to the adequate maintenance of the road surface or wearing course.

Let us then proceed to outline the various kinds of work which properly come within the scope of this subject, after which we may go into the details of just how this work is being done, using the methods followed in Kent County as a guide. The various subdivisions of

maintenance referred to include the following:

Guard Rail Maintenance.
Shoulders and Washouts.
Care of drainage Structures and Side Ditches.
Maintenance of Markers and Signs.
Cutting of Weeds and Brush.
Forestry and Landscape Work.

There are a number of other items of maintenance work which could be included in this list but as they are more or less, special cases and not a general interest, we shall stick to the six subdivisions just referred to as far as this paper is concerned. A study of the past four years' maintenance costs of Kent County shows that these six subdivisions of work make up about 30 per cent of the total maintenance cost. Incidentally it is worthy of mention that the cost of a majority of this work is a fairly constant factor, not greatly affected by the type of road surface or the volume of traffic.

Guard Rail Maintenance

The maintenance and proper care of guard rails consists mainly in rebuilding broken sections from time to time and in painting frequently enough so that they are plainly visible at night. Broken portions of guard rails should be rebuilt and painted as soon as possible after the damage has been done. In order to do this economically it is necessary to keep a supply of guard rail posts, lumber, cable and fittings on hand at all times. It is usually advisable to buy the posts and lumber in carload lots. If the repair work is on roads which are maintained by truck patrols, the material can be taken out to the desired points by the scraper men. The men who do the repair work can then drive an ordinary passenger car from place to place as they make the necessary repairs, thus saving the cost of operating a separate truck for this work. In other cases a guard rail repair crew of about two men, equipped with a light truck, can handle this kind of work very nicely, and carry all of their materials with them.

The manner in which guard rail painting should be handled depends largely upon the quantity of guard rail to be painted. If the quantity is small, it is only necessary to send out a couple of men with a light car carrying their supplies with them and doing the painting by hand. For larger quantities of guard rail, a spray machine should be used. Proper equipment for this work would consist of a 1 or 1½-ton truck with platform body on which would be mounted a small engine and air compressor outfit of sufficient size to operate two lines of hose. The paint tank should hold about 5 gals., this being a convenient quantity of paint to mix at one time. The best outfit is one with the engine, compressor and paint tank all compactly mounted on a small 4-wheeled truck. This kind of an outfit can be quickly removed from the motor truck, thereby releasing the truck for other work when rainy weather or other conditions make it inadvisable to paint guard rails. The paint crew should consist of two men, one to drive the truck and paint the inside rails, the other to work on the outside of the guard rail continuously.

A crew and equipment like this can paint nearly a mile of wooden guard rails in a day at a total cost slightly over 1 ct. per lineal foot, including paint. In order to do this it is necessary to buy a first class lead and oil paint, such as would comply with the present Michigan Specifications for guard rail paint.

As a rule guard rails along gravel or dirt roads which carry a fairly heavy traffic should be painted every year. On paved roads, or other types which are not dusty, it is usually sufficient to paint them once in two years.

Shoulders and Washouts

The work involved in maintaining the shoulders of the road and taking care of washouts is in most cases a matter of hauling dirt or other material and placing it in V-shaped depressions which have been caused by the action of water. Some of our more heavily traveled paved roads, however, present greater difficulties. For instance, some of the old 16 ft. concrete roads which are now carrying 4,000 or more vehicles per day are handling quite a volume of traffic on the shoulders. It is sometimes necessary in cases like these to use large quantities of gravel on the shoulders and to install a regular patrol system of maintenance to keep it smooth. For the purposes of this paper, however, let us consider shoulder maintenance as being in the class first mentioned, assuming that the latter type of work should be charged to the surface or wearing course.

For reasons of safey and convenience it is very important that shoulders be maintained at all times in a condition fit

to be traveled upon. To obtain this result, it is necessary that the maintenance organization be prepared to go out on short notice during and following storms with the proper men and equipment to take care of this work. At such emergency times men should be sent out ahead of the regular maintenance crews to put up lanterns, red flags, barricades, etc., to warn traffic of the dangerous places. Ordinarily, the crew or unit to do the work consists of a motor truck and two or three men. The number of units sent out depends entirely upon the volume of work to be done. These crews obtain dirt or other material as close to the washouts as convenient and dump it into the holes, smoothing it up with hand shovels so as to leave the shoulders and grade in good condition again. Sometimes the side ditches are eroded so badly that something must be done to prevent further washing. This can be taken care of in a number of ways; namely, by placing stone, rip-rap, cobble gutters, sod or brush. It has been the experience of the writer that brush, properly placed, is about the most economical and effective method in most cases. Washouts in the backslopes of cuts can usually be prepared against further erosion by cutting ditches along the tops of the slopes and parallel to the centerline of the highway which will lead surface water away from the points which have been giving trouble.

Washouts on the shoulders can be greatly reduced by keeping the shoulders a little low for some distance each side of the low points in grades, thus permitting the water to run off at many points instead of collecting at one place and tearing out a large hole. Sometimes it is advisable to follow an entirely different plan where we have deep valleys with steep grades leading into them from both ways, especially if the shoulders are built of sand or other unstable material. In these cases the shoulders should be kept a little high so as to lead all of the water to the low points, and at such points there should be constructed wooden or concrete chutes or possibly catch basins to take the water away from the road without damage to the shoulders. These are only a few of the more common methods of handling this kind of work. Each heavy storm, however, presents many and varied new problems which give the maintenance superintendent a splendid opportunity to use his ingenuity.

Care of Drainage Structures and Side Ditches

It is obvious to anyone that the proper care and maintenance of drainage structures, especially under heavily traveled roads is of paramount importance. The highways of practically any county contain culverts of all types and sizes. It is necessary then that we have available culvert materials of many different kinds and men with the right equipment and knowledge to handle them. In the case of concrete culverts which are failing, for one reason or another, it is often possible to prolong or delay the failure many years by bolstering up the present structure in a rather inexpensive manner. The exact work to be done is usually different for each case, and must be determined by the man in charge. For this work, as well as for concrete culverts which must be replaced by new ones, we must have equipment for mixing and placing concrete in comparatively small quantities. This calls for a truck equipped with a dump body for hauling materials and a concrete mixer of about 1 sack capacity. The mixer and engine to run it should be mounted on wheels so that it can be easily loaded onto the motor truck, and quickly transported from one job to another. The crew generally consists of a foreman, truck driver, carpenter, and two or more laborers. A crew of this sort can build headwalls, repair old concrete culverts and build new culverts up to about 12 or 15 ft. spans. It is the belief of the writer that replacement jobs much larger than these can be more economically handled by contract, after having received competitive bids. On all concrete work which is being handled by maintenance crews, the same rigid inspection of materials and workmanship should be furnished by the engineering department as is usually furnished on contract work of a similar nature.

For failures in culverts of sizes up to 36 in. and in some cases larger the replacement may be of encased tile, reinforced concrete pipe, corrugated metal or cast iron. If only a portion of the culvert has to be replaced, it is generally best to replace with the same material as the balance of the culvert. If the whole culvert has failed it is usually better to replace with something besides encased tile, as this type does not lend itself to maintenance work as well as one of the other types which can be

placed without the use of concrete mixed on the job. It is also recommended that all driveway culverts be constructed without concrete headwalls. Field stone, laid up dry, around the ends is much less expensive, equally as satisfactory and better looking. Without concrete headwalls these culverts can be moved, lengthened or repaired without any loss of salvaged material.

In all of this culvert repair or replacement work it is important that the work be done with the least possible interruption to traffic. The circular culverts can usually be placed under a half of the road at a time leaving the other half for traffic. The concrete culvert jobs, however, present a more difficult problem. Generally it is necessary to construct a temporary bridge or by-pass to carry traffic. The character of the detour constructed or the amount of money spent on it, is largely dependent upon the volume of traffic which the road carries. It goes without saying that in all cases it is imperative that the proper attention be given to the correct use of signs, lights, barricades, etc., to warn and direct traffic.

No matter how well the drainage structures are maintained they cannot furnish satisfactory drainage service without the proper attention to inlets, outlets, and side ditches so as to allow the free flow of water. As soon as possible after the snow has left in the spring, men should be sent out on all of the roads with definite instructions as to where and what to do to properly take care of this phase of the work. About all the men need is transportation facilities, shovels to work with and proper instructions. This same plan should be followed out again in the fall just before freezing weather. Sufficient attention to this part of the work will save many times its cost later on in other branches of the maintenance problem.

Maintenance of Markers and Signs

During the past few years a fairly complete system of markers and signs has been installed on the state trunk line system of Michigan. Many of the counties have followed suit and now have a complete signing system on their county roads. Without adequate maintenance, however, such a signing system becomes almost worthless in two or three years. As the plan of caring for these signs must necessarily vary a great deal under different conditions I will proceed to outline the methods followed in Kent County and leave you to draw your own conclusions as to how it should be done elsewhere.

To begin with, the maintenance superintendent is assisted by four district superintendents. Each district superintendent is provided with a car and required to look after all maintenance work in his district, which, in each case, comprises about one-fourth of the county and includes 110 to 115 miles of county and state trunk line roads. He covers all of the roads in his district nearly every day, and at least two or three times a week he has occasion to visit the main plant in Grand Rapids.

The signs themselves are just naturally divided into two classes. We have the danger and warning signs, which are made of cast iron, and the distance and direction signs, which are stamped metal plates fastened with brass screws to a board back. Both classes of signs are fastened to cedar posts. The cast iron signs are rather expensive and it is therefore necessary to repaint them every year or two in order to keep them looking good. The plates for the other class of signs are comparatively inexpensive, however, and it is found to be more economical to buy new plates than to repaint the old ones. This condition has resulted in the county maintaining a small stock of both classes of signs on hand at all times.

As the district superintendent goes about his work he makes a note of any signs which are in need of replacement or repainting. In a day or two, when he is at the main plant in Grand Rapids, he procures from the stockroom the particular signs he wants. The plates which he receives are new ones and the cast iron signs are probably repainted ones. He carries these signs along in his car, and whenever he comes to one of the poor signs out on the road, the old sign is simply replaced by a new or repainted one, and the old sign taken along back. The old plates are thrown away and the old cast iron signs are taken back to the stockroom on the next trip in. Whenever a sufficient number of the danger and warning signs have accumulated at the stock room, a sign painter is set to work repainting them and then they are again placed back in stock to wait for another trip out. This plan of handling the sign job has worked out quite successfully in Kent County and undoubtedly has some distinct advantages for a county organization.

First, there is no lapse of time when a post is without a complete sign. Second, the work of replacing and transporting the signs does not require special trips by anyone, and is therefore economical. Third, the repainting of old signs is accomplished under more favorable conditions with more speed and better quality of work. Fourth, the weather is not a factor to be reckoned with as is the case where signs are painted out on the road.

Although this plan of handling sign work is apparently very economical, economy is not its greatest asset. The chief advantage lies in the fact that the signing system does not have to wait for a general overhauling but is taken care of promptly and continuously, maintaining a complete and good looking system of markers and signs at all times.

Cutting of Weeds and Brush

Only a few years ago it was the exception rather than the rule to find a road with clean looking shoulders and the roadside free from noxious weeds and brush. Today we find a different landscape. The county which does not take care of its roadsides is considered to be negligent in its duties and a back number in highway maintenance work. In order to obtain the maximum use and safety of the highway it is absolutely essential that the shoulders be mowed frequently. To prevent the spread of noxious weeds and to keep the highway looking right, it is necessary that the right-of-way outside of the shoulders be taken care of.

The shoulders should be mowed at least three times during the season. A good time to start this work in this part of Michigan is about the last week in June. All of this shoulder mowing, the first time over, should be completed in about two weeks, and the organization and equipment should be worked out accordingly. About a month later, the shoulders should be gone over again. The third and last mowing should be done about the last of August or the first of September. These dates are of course only approximate, as they would naturally vary with seasonal variations. The number of mowings are about right, however, for most roads in this part of the state. This work has quite generally been handled with teams and ordinary mowing machines. In a few places Fordson tractors with mower attachments have been used. Both methods are satisfactory.

The right-of-way between the shoulders and the fences is usually of such a nature that mowing machines cannot be used, and consequently the mowing must be done by hand. There is no great haste about this work, and it is ordinarily satisfactory to start about the first of July and finish about the last of August. One mowing is sufficient, and it is not necessary to cut the grass. As a matter of fact, it is probably better to cut only the weeds, leaving the grass to go to seed. If this method is followed a few years will usually see the roadsides well sodded over with practically all of the weeds crowded out. Incidentally, this plan of mowing will probably cost less than half as much as the cost of mowing the roadsides clean, grass and all.

There is not much choice as to the manner of handling this work. The usual and probably the best plan is to place a sufficient number of men out on the roads with scythes to complete the job in the time required. Men can ordinarily be obtained at laborer's wages to do this work and furnish their own transportation.

Forestry and Landscape Work

A phase of our highway maintenance work which has not received the attention it deserves is that pertaining to the beautification of our roadsides. In this state, which we boastfully call the "Playground of a Nation," we are year after year passing up one of our greatest opportunities. And that is the opportunity to make our roads attractive to the outsiders, as well as ourselves, by properly caring for what nature has already placed on them in the way of beautiful trees and shrubs, and by planting more in the barren stretches. The satisfaction which we, ourselves, can get from our own beautiful and well kept highways should be sufficient cause for action along this line, especially when we consider the low cost of the work, but when we find, as we already have found, that in this state it will pay out in dollars and cents, there should be no hesitancy in going ahead on a conservative and sound policy of this so-called beautification work. It is important that we keep our roadsides, as well as the traveled portions of the roads, attractive in appearance as it is the beauty of our state which attracts visitors and tourists.

Only a few of the counties in the state have gone into this sort of work to any great extent. Kent County has been one

of the pioneers, having employed a forester and carried on roadside beautification work since the summer of 1921. At the beginning of the work it was decided that the first and most important thing to do was to properly care for the existing trees and shrubs before going into any extended tree planting program. The years which have gone by have shown the wisdom of this plan. The roads of Kent County can now speak for themselves as to the results accomplished. In starting out on a tree planting program, it must be remembered that no results can be expected from the standpoint of the looks of the highway in less than about 10 years time. On the other hand the proper trimming and care of existing trees and shrubs give immediate results. Of course, if funds are available for both kinds of work so much the better, but as a rule this is not the case at the beginning of the work. In the construction of new roads it has been necessary to remove but a comparatively few trees or shrubs of any ornamental value. Only such trees that interfere with the actual construction work or with traffic are removed. The trees or shrubs which add any beauty to the road or surrounding landscape have been saved where possible and in some places changes have been made in the alignment of the road to avoid the destruction of groups of trees. The policy of the Kent County Road Commission has been to keep all roads open to traffic throughout the year, and it has been necessary to cut shrubs or groups of shrubs which cause drifting of snow upon the highway. While this has been found necessary in some instances, it has been found that in numerous other places the shrubs or groups of shrubs actually prevent snow from drifting by acting as a windbreak. In the case of newly constructed roads they are all thoroughly gone over by the forester and his trimming crews immediately after the road has been accepted from the contractor.

Kent County is unusually fortunate in having a great number of large beautiful trees along practically all of its highways. These trees, many of which were planted by the old settlers, were very often neglected after planting and as a result when the work of preserving these trees and shrubs was started they were badly in need of care. At the present time the entire mileage of state trunk lines and county roads on the Kent County Road system has been trimmed at least once and about 75 per cent of the mileage has been gone over the second time, with the result that all highways so taken care of now present a very marked improvement in appearance. The improvement, however, is much more noticeable as time goes on than it is just after the first trimming has been done as the trees and shrubs, after trimming, often take on new life and present a more thrifty and healthy appearance.

The trimming work which has been done has consisted in the cutting out of dead, diseased, and superfluous branches, removing dead trees and shrubs, cutting off low hanging branches which obstruct traffic or corner views, and properly pruning and thinning all existing small trees and shrubs found on the right-of-way. All road intersections and corners have been cleaned out and cleared of all obstructions, giving the motorist sufficient view to prevent accidents. It is interesting to note that during the past year in Kent County no accidents have been reported due to obstructions at road intersections, corners, and railway crossings. This situation has never existed previous to 1925 and as there has not been a general decrease in the number of accidents we can safely draw the conclusion that the work of cleaning out corners, etc., is directly responsible for elimination of accidents at the points referred to.

In the development and preservation of our roadsides it has been necessary to ask the co-operation of pole using companies. The manner in which they have co-operated with us during the past four years has been very satisfactory. They have spent large sums of money in rebuilding and re-locating pole lines at our request so that at the present time their interests conflict with ours in very few instances. On all roads which have 100-ft. right-of-ways there is room for trees and shrubs as well as for pole lines. In locating pole lines on right-of-ways of 66 ft. there is no hard and fast rule to follow as this width of roadway is too narrow for use of pole lines without some interference of trees. The lines must, therefore, be located where they will interfere the least with the trees and at the same time be safe for traffic.

Due to the fact that it has been deemed more important to maintain the trees and shrubs we already have, not much planting has been done as yet although several small stretches of road-

sides have been planted. In planting a roadside it is well to keep in mind to plant the proper species of trees. This can be best determined by observing what species of trees thrive best in the direct vicinity in which the planting is to be done. For handling this trimming work our forester has been furnished with a 1½ ton truck and the necessary tools which he needs in his work. While this truck is light enough to get to and from the work quickly it is also heavy enough to transport all the tools and the required number of men. A crew of 6 to 8 men with the equipment just referred to works steadily on the trimming of trees and shrubs from spring to late fall. The work of cleaning out corners and intersections is usually handled by one or two men working separately and traveling from one place to another in their own cars.

Since June, 1921, Kent County has spent for all purposes in connection with forestry and landscape work along the highways a total of $27,000. This cost has trimmed 450 miles of roads once and about 300 miles the second time. It also covers cost of cleaning out corners and intersections and the establishment of a number of wells in miniature parks at a number of points along the highways. Some of these little parks, which were established on corners where excess right-of-way had been purchased, are now very good to look at and help to relieve the sameness and monotony of many of our highways. The cost of trimming this 450 mile road system the first time over averages approximately $40 per mile. The retrimming work costs about $5 per mile. It has been planned to go over the entire country road system from now on every year and do the necessary trimming and other forestry work which shows up from year to year. It is estimated that this work will cost $5 per mile or less per year.

CONSTRUCTING ASPHALT TENNIS COURTS

By W. E. Rosengarten, Engineer, The Asphalt Association, New York, N. Y.

Interest in lawn tennis has been increasing in recent years, and with it there has developed a strong desire for more nearly perfect court surfaces. The qualities which are sought are greater smoothness than can usually be retained in the ordinary sand clay tennis court, and greater firmness and resiliency. Paved surfaces, particularly those of asphalt, permit of fast and true play without serious fatigue or injurious effect upon the players. An important consideration from the standpoint of ultimate economy is the construction of a surface that can be kept in perfect condition at small labor and expense throughout the playing season.

Of the many thousands of tennis courts that exist throughout the United States only about 10% have been given hard, smooth, paved surfaces and the trend toward the best in tennis courts is, I believe, therefore, only in its initial stages. The most satisfactory results thus far obtained in modern playing surfaces are with some form of construction either of asphalt, sand and stone mixtures or macadam bound with asphalt and constructed similarly to the paving on our streets and highways. England has made extensive progress in this direction and has not only reached a high degree of efficiency in constructing and maintaining asphalt tennis courts but has obtained some very beautiful effects by incorporating into the finished surface red crushed tile, or treating it with a green solution, thus presenting a very pleasing color scheme either contrasting or harmonizing as desired, with the borders and terraces of green turf.

While there are asphalt paved courts located at Detroit, Michigan; South Bend, Indiana; Calgary, Canada, and other points, they are most common in the Pacific Coast section of the country. Their general use there is due largely to the fact that in California is obtained an abundance of petroleum which yields asphalt, a popular and readily available local product. Because of the greatly increased use of asphalt for paving and roofing within the past few years and the establishment of asphalt plants at convenient points, sources of supply and competent construction facilities for asphalt courts are now within easy reach of any community. While the greater portion of the asphalt supply in the United States is obtained from Mexico, petroleum asphalt is also obtained from the middle west, southwest and the Pacific coast and Rocky Mountain sections.

Asphaltic tennis court surfaces are waterproof and, in consequence, not only are the courts available for play within 10 or 15 minutes after a rain, but the surface is thoroughly protected

against washing or disintegration such as are frequently caused by heavy downpours on sand clay or earth courts. A maximum smoothness is obtainable in the asphalt playing surface and this smoothness is retained throughout the play on account of the fact that the powerful adhesive character of the asphalt prevents any displacement of the surface material. Asphalt is a flexible and resilient material and makes possible long and continuous periods of play without tending to tire out or stiffen the players. The freedom of the surface from sharp, angular fragments or from rigid, gritty texture tends to conserve the soles of the players' shoes as well as the tennis balls, since there is practically no abrasion.

While the original cost of an asphalt court is somewhat greater than a sand clay or gravel court, the initial cost is retrieved in a very short time because a properly constructed asphalt tennis court requires practically no upkeep.

Methods of Construction

Proper drainage is of primary importance for an asphalt tennis court just as it is in the proper construction of a highway. In sandy or gravelly soil the drainage problem is not serious and the water drains away easily and naturally. Soils in which clay predominates, however, will retain water and unless proper drainage facilities are provided the wet subgrade under the surface will not provide sufficient support for the pavement. Where such a soil is encountered drainage is obtained by digging a ditch 2 or 3 ft. deep along each side of the court and giving to these ditches a slight grade or fall in the direction of the general slope of the ground. In the bottom of these ditches there should be laid a small-sized, open-joint tile after which the trenches should be back-filled with broken stone to within a few inches of the surface. This drainage system will collect the ground water and lead it away from the subgrade. Drainage of surface water from the court itself will be obtained by giving the finished surface a slight slope of 1 in. for each 10 ft. of distance.

In the construction of the tennis court the subgrade should be leveled and finished to an elevation such that when the playing surface is applied the latter will be flush with the shoulders or the surrounding sod, thus permitting an uninterrupted drainage of surface water after the court is completed. Where fills are made they should be thoroughly compacted and allowed to stand until they have been subjected to several heavy rain falls before surfacing is attempted. The paved area of a tennis court should be 60x120 ft. As the outside dimensions of a double playing court are 36x78 ft., such a paved area will afford ample room for play outside of the lines.

After the grading and drainage work has been completed and the subgrade is dry and compacted, a foundation course of steam cinders of from 4 to 6 in. in thickness may be applied to good advantage. Ashes from house furnaces are not desirable for this purpose. The cinders should be thoroughly compacted by sprinkling with water and rolling. Too much stress cannot be laid upon the importance of a thorough rolling since it consistutes insurance against trouble later from the settlement of the paved area. Equal, if not better, foundations can be obtained through the use of crushed stone, gravel, slag or similar local materials, or from a 3 in. bed of portland cement concrete. A superior type of foundation may be laid if an asphalt paving plant is accessible by laying a mixture of stone and sand bound together with asphalt according to up-to-date paving specifications and at a thickness of about 2½-in.

As suitable a type of surface course as can then be laid upon the foundation is the sheet asphalt pavement similar to that which is commonly laid on great thoroughfares like Fifth Avenue, New York. This consists of a mixture of hot sand, limestone dust and asphalt cement, and should be laid to a thickness of from 1 to 1½ in. This material should be prepared at a mixing plant. Asphalt paving contractors are, of course, quite familiar with this type of construction and complete information can be obtained from them as well as the local engineer in charge of city, street or country highway paving.

Where the base course is of broken stone or cinders, it will be desirable first to lay what is known as a binder course about 1 in. in thickness upon the foundation before laying the sheet asphalt surface course. This binder course is similar to the asphaltic base mixture mentioned above. It consists of stone ¼ in. to ¾ in. in size, which is mixed with sand and asphalt cement and laid in the same manner as later described for the sheet surface course. The binder

course mixture should have the following proportion by weight:

Stone retained on a sieve having 10 wires per inch, 60 to 80%. Sand passing a sieve having 10 wires per inch, 15 to 35%. Asphalt cement (pure bitumen), 4 to 6%.

The sheet asphalt surface course, which will not require the above described binder course if the foundation be of asphaltic concrete or portland cement concrete, should be from 1 to 1½ in. in depth. In order to obtain the best results a carefully graded sand should be employed. This, when mixed with the asphalt and limestone dust, which should pass a sieve having 200 meshes per inch, should give a mixture which will have the following composition by weight:

Sand passing a sieve having 10 meshes per inch and retained on a sieve having 40 meshes per inch, 10 to 40%.

Sand passing a sieve having 40 meshes per inch and retained on a sieve having 80 meshes per inch, 22 to 45%.

Sand passing a sieve having 80 meshes per inch and retained on a sieve having 200 meshes per inch, 12 to 30%.

Dust passing a sieve having 200 meshes per inch, 10 to 20%.

Asphalt cement (pure bitumen), 9.5 to 12%.

The asphalt cement for both the binder and surface courses should be of a consistency such as to show a 50 to 60 penetration test when used in warm climates and from 60 to 70 when used in cold climates where the temperature falls below 10 deg. F.

The above mixture should be prepared at a paving plant where the sand and asphalt can be heated to approximately 350 deg F. A temperature above 400 deg. F. is not desirable since it tends to injure the asphalt. The quantity of asphalt paving mixture necessary for one or two tennis courts would hardly be sufficient to justify the setting up of an asphalt paving plant, it is therefore desirable to obtain the mixture either from a municipal plant or a contractor's street paving plant in the vicinity. After it is prepared the mixture can be hauled hot by truck any distance ranging up to 20 miles if necessary.

Where a hot-mix asphalt plant is not available a cold mix may be made with especially treated asphalt products known as emulsified asphalts and cutback asphalts which are liquid at ordinary temperatures. Satisfactory materials of this kind are on the market and can be mixed with unheated sand to produce a paving mixture that will harden in a few days and produce a stable surface.

The surfacing material should be dumped from the trucks upon boards or platforms from which it can be spread by shovels over the prepared foundation course and then raked to a depth such that after rolling it will be at least 1 in. thick. Rolling should follow shortly after the spreading and while the mixture is still pliable. Thorough compression is essential and while heavy hand rollers will give satisfactory results it is preferable to use a power roller of at least five tons' weight if one is available. After thorough compaction has been obtained it is desirable to sweep over the surface a sprinkling of limestone dust or portland cement and to finish the surface with a final rolling in all directions diagonally and longitudinally.

An asphalt surface does not produce glare under sunlight. It has a dark gray color that is restful to the eye. In some cases, however, it has been thought desirable to tint the surface with a green cromic oxide paint to give it more nearly the appearance of the grass court. Various other solutions are also to be found on the market for this purpose and can be applied by means of a forced spray. The lines are marked out by means of stencils with a solution in white. The best results are obtained by applying the solution in two thin coats. The second coat should not be attempted until after the first has thoroughly dried. On some courts a special finish has been used which gives the surface a pleasing color of deep red.

The penetration method of construction is also used sometimes for court surfacing. The usual procedure is to spread a uniform course of crushed stone 1½ to 2 in. in thickness upon the foundation of cinders, crushed stone or gravel. The stone used should be ¾ to 1¼ in. in size and should be rolled sufficiently to set it in position. Over the dry stone, which should present a firm, true surface of even texture, is poured asphalt cement heated to about 300 deg. F. The asphalt cement should be of a consistency that will give a penetration test of 100 to 150. About one-sixth of a gallon of asphalt per square foot will be required completely to coat the stone in this surface course. A cover of stone

chips usually is spread over the surface, followed by thorough rolling. A hot hand-roller has been found to give sufficient compression, but a 5-ton roller is preferred. In order to obtain a smoother surface it is sometimes desirable to apply a second light coating of asphalt cement. This treatment is but one-fourth as much as the first and is covered with fine stone chips and finished by thorough rolling. The penetration type courts have turned out to be very satisfactory but since the surface is not as accurate as that obtained from the mixed types, the penetration court generally is not used for tournaments.

The accompanying table gives the quantities of materials required for the courts above described.

Another and less expensive method of obtaining a desirable tennis court surface is that of the treatment of a sand clay or gravel base with an asphaltic oil. For a new court it is preferable to construct in the usual manner a gravel or sand-clay base and use it for several months so that it will become thoroughly set. The surface is then dragged and carefully brought to a true plane. Upon this is sprayed a light coating of asphaltic oil at the rate of about 0.03 gal. per sq. ft., or a total of about five barrels for a court 60 ft. by 120 ft. This surface is then covered with fine stone chips or coarse sand and is allowed to stand for 24 hours. About 1½ to 2 tons of cover material are required to each barrel of asphaltic oil used. A roller, if available, may be used to advantage. The asphaltic material may be a liquid which can be applied cold, or on a gravel surface a somewhat heavier asphaltic oil which must be heated before application can be used. When the lighter oil is used, renewed applications will be required about every year, while with the heavy hot oil several years may intervene between applications. And after several treatments a lasting surface will have been built up.

FOR ASPHALT TENNIS COURTS—QUANTITIES OF MATERIALS REQUIRED
(Per square foot of paving 1 in. thick)

Material	Compacted Foundation per 1 inch Thickness	Asphaltic Binder Course per 1 inch Thickness	Sheet Asphalt Surface per 1 inch Thickness	Penetration Macadam Surf. per 1 inch Thickness
Crushed Stone	10.0 lbs.	8.6 lbs.	.....	12.0 lbs.
Sand	.....	3.3 lbs.	8.5 lbs.	.....
Stone Dust	.....	.....	1.6 lbs.	.....
Asphalt Cement	.....	0.7 lbs.	1.2 lbs.	0.9 lbs.
Total	10.0 lbs.	12.6 lbs.	11.3 lbs.	12.9 lbs.

Note—Stone weighs (loose) 2,400 to 2,800 lbs. per cu. yd. Sand weighs from 2,300 to 2,600 lbs. per cu. yd. Asphalt weighs from 8.3 to 8.8 lbs. per gallon.

BLASTING BIG DITCH AT TYLER, TEXAS

By Harry C. Grace, City Food and Dairy Inspector, Tyler, Tex.

Tyler, Texas, is a city of about 18,000 population, located on a series of red sand and clay hills, which form the Neches and Angelena River water shed. The small valleys between these hills are plentifully supplied with springs which have never been known to go dry. The springs form small streams and flow northeast to the city limits where they run together and make what is known as the Black Fork Creek. After passing out of the city limits this stream turns and runs along the northern edge of the city.

It then flows through a valley with high red hills on both sides and has a fall of about 12 ft. to the mile. One of the unusual features of the stream is that it spreads out over the valley between the hills, reaching a width in some places of 4,000 ft. and having an average width of about 2,500 ft. The depth varies from 6 in. to 5 or 6 ft. The soft mud under the water is about 18 in. deep. The bed of the stream is covered with rushes and willow brush.

One of the worst features of this swamp is the fact that it has been used as an open sewer for the city for many years and for the last ten years the waste matter from the disposal plant has been emptied into it. This was, of course, not nearly so offensive as when the raw sewage has been dumped into it previously; but the conditions, due to the fact that no chlorine had been used, that there was plenty of shade and lack of fish control, made it an ideal breed-

ing place for mosquitoes. In this water we found the "Three Muskeeters"—the cules, aedes and anopheles mosquitoes. The cule and aedes are seldom found in swamps but breed in rainwater barrels and similar places. The cule is suspected of carrying dengue fever. The anopheles carry malaria and breed only in swamp water.

In our plans to drain this swamp, we hoped to eliminate the mosquitoes and to cause the stream to run swifter so that the tumbling motion of the water will do away with the odors from the Imhoff Tank and the gases from the decayed sewage dumped in former years. After a thorough inspection of the situation and a consideration of various methods, we determined to use dynamite as the agent to blast out the kind of ditch we desired.

In doing this work we used one ton of the explosive which cost us, together with fuse and caps, $420 delivered. The cost of labor was about $60, making a total of $480. We succeeded in digging a series of four ditches with a total estimated length of 5,000 ft. This cost us about $96 per 1,000 ft. or $9.60 per 100 ft. of ditch. The ditch averaged about 4 ft. deep, 4 ft. across the bottom and 6 ft. wide at the top. We found that one big advantage of ditching with dynamite was that no spoil banks or piles of dirt were deposited along the sides of the ditch to flow back in again and fill up the stream. This dirt was scattered widely over the landscape, leaving a clean ditch.

In building our ditch we ran a straight surveyed line wherever possible, and in this way found we were compelled to cross several dry raised places in order to straighten bends. These dry places required nearly twice as much dynamite, but the result was a wonderfully straight ditch. Where the ground was wet we placed the dynamite cartridge about 15 ins. apart and about 15 ins. in the ground. We used one stick to the hole in the wet places and two sticks to the hole where the soil was dry. We shot about 200 ft. at a time and in this way were able to start at the lower end and keep some of the water drained out so that it would not come over our hip boots. Where we found timber we cut a roadway so that the limbs would not interfere with the dirt when the dynamite raised it. We believe it would have been impossible to have dug this ditch with labor at a price less than $1,000, and I do not think that we could have induced men to work in this filthy water.

The result of our blasting is that we have drained some very valuable land which can be cultivated next year and perhaps this year. We have had one flood after another and the ditches are open and hard at work. The rains helped to move the loose dirt that the dynamite did not throw out but loosened.

We still have a large part of this swamp to ditch and we think we shall be able to do it the coming winter. We were unable to complete the job on account of lack of funds, but we are hopeful that the budget next year will carry the necessary money which will be used to purchase dynamite.

We found that the ditching with dynamite was very successful. It proved to be much cheaper and in every way more satisfactory than any other form under the conditions.

This is especially true where, as in our case, water covered the ground and the mud made it nearly impossible to use men or machinery.

KLAMATH RIVER HIGHWAY BRIDGE

Forty-five miles south of the California-Oregon state line, the waters of the great Klamath River merge with those of the Pacific Ocean. The Klamath is one of the least known rivers of California. Rising at a high altitude in the snows of the Cascade Mountains which surround the Klamath Lake region in southern Oregon, it flows for almost its entire length through deep, rugged canyons and virgin forests of giant trees.

The Klamath is bridged in but few places. Most of the existing bridges are of the suspension type, built high above the waters, which sometimes rise as much as forty feet in flood stage. This great river, with its antiquated ferries, operating only in fair weather, has been a barrier which has effectively isolated Del Norte County from the remainder of the state.

The late Dr. Douglas was persistent in his efforts to obtain recognition of the necessity for a great bridge near the mouth of the river which would link Del Norte County with the improved high-

way system of the balance of the state, and indications pointed to his success during the 1923 session of the legislature. However, before the culmination of his efforts, he died suddenly in Sacramento, mourned by all who knew him.

The untimely death of Dr. Douglas sharply impressed the necessity for the bridge upon the attention of his colleagues in the legislature. Governor Richardson had previously approved the project, and under a suspension of the rules, the bill which Dr. Douglas had introduced was passed and signed. It appropriated $225,000, not only to reward the efforts of Dr. Douglas in representing his community, but to construct a fitting memorial to his memory.

Bridge Considered for Many Years

The bridging of the Klamath River, thereby connecting Route No. 1 throughout its length, has long been an ambition of the engineers of the California Highway Commission. Surveys, studies, and soundings have been made during the past ten years, preliminary to deciding upon the type of bridge and the proper location. The route was authorized by the 1909 highway bond issue; the Highway Commission was, therefore, able to supplement with bond funds the appropriation provided by the legislature. The special appropriation of $225,000 made the bridge possible, although the contract was awarded for $391,000.

The Douglas Bridge spans the Klamath about 3 miles from its mouth, at a point where the river is nearly a quarter of a mile wide. Heretofore, the river has been crossed by a small ferry which could not be operated at times of extreme high or extreme low water.

Steel was the structural material first considered for construction of the bridge, but when the memorial features were introduced, it was decided the structure should be of concrete. The bridge, now approaching completion, consists of five main arch spans, each 210 ft. in length, with short approach spans at each end. In some respects, the structure is unique, and the only one of its kind in the world.

Much objection was presented by engineers to prove the impossibility of bridging the wild floods of the Klamath River with concrete arches; the current was too swift, the floods were too great, the drift too heavy (frequently full sized redwood trees, some as great as 15 ft. in diameter, are floated down the river with their roots dragging). The concrete arch spans, it was said, could not be built high enough or long enough to pass such drift; also, there was only an unstable sand and gravel bottom on which to build such mammoth arches. It was pointed out that nowhere in the world had such large concrete arches been successfully built on such foundation.

Memorial Features Determine Design

The Bridge Department of the California Highway Commission was not daunted by such objections. The problem was approached by the bridge engineer and his assistants with the same conservative assumptions as have for the past fourteen years insured the stability of structures built under the direction of the commission. Comparative cost estimates of a steel structure and various combinations of concrete structures were made, the memorial features of the structure always being borne in mind. Final decision was made on a bold design of massive concrete arches founded on deep piles, surrounded and protected by cofferdams driven to refusal in the sand and gravel at the bottom of the river.

Carefully checked measurements were constantly under way during construction, and the centers were struck in the false work without apparent settlement of the arches. The bridge will stand for all time as a suitable and beautiful memorial to Dr. Douglas.

Throughout two winters, while under construction, this bridge has withstood floods, as great as ever have come upon this river, with absolutely no damage. The most delicate of engineering instruments have not detected any settlement either of the arches or the foundation. Each pier of the bridge rests upon 150 piles, each pile hammered to refusal under repeated heavy blows. The piers are as firm as though built upon solid rock. This is an unusual record for foundations on bridges of this type. Even the designers expected some settlement when the heavy arches first carried the load for which they were designed.

The completion of Klamath bridge will close one of the few remaining gaps in the Coast state highway between San Francisco and Portland, Oregon. It will also open to the motorists of California and the Nation a vacation land of virgin woods and mighty streams, the like of which is to be found nowhere else. To

some it is a region for care free outdoor sport, to others a land of dreams, a place for solemn communion with the everliving redwoods of a forest primeval whose mysteries of life go back beyond the time of civilizations now gone from the earth. Whatever appeal this north coast section of California may make, it is one of unequaled boldness and beauty, unsurpassed in any section of the West.

The bridge now nearing completion will be ready for final acceptance later in the summer.

PAVING AT THE NEW DELAWARE RIVER BRIDGE

The new highway linking Pennsylvania and New Jersey at Camden and Philadelphia made possible by the new Delaware River bridge will be opened shortly. Plans are under way for the opening to take place July 1, and the engineers at this time see no obstacles in the way of carrying out the plans. A recent inspection has revealed rapid progress being made. Paving, which is necessarily one of the last steps, is well under way, both at the approaches and on the main span of the bridge. On the approaches the paving is of granite block. A special size block is used, from 3½ to 4 ins. in depth, 3¾ to 4½ in width and 7 to 11 ins. in length. These blocks are bedded in a 1 to 3 in. sand cement cushion and the joints are filled with an asphalt sand grout. This grout is composed of 60% sand and 40% petroleum asphalt, having a penetration of from 50 to 70. On the colder days when the work was begun a grout of half sand and half asphalt was used. The asphalt grout filler was mixed in a machine consisting of a cylindrical bottom tub about 4 ft. in length, in the axis of which revolved a shaft carrying a number of blades set at an angle to mix the ingredients and at the same time work them forward to the discharge end. It was drawn off into two wheel buckets and dumped upon the surface of the block. The grout was then worked into the joints by the use of squeegees.

On the main span, which is 1,750 ft. in length, sheet asphalt paving is being used. This is being laid with a binder course 1½ ins. in depth and a sheet asphalt top 1 in. in depth. Owing to the width of the roadway (57 ft.) it was found necessary to carry the work ahead, spreading and rolling half the width at a time. A heavy rope was temporarily used to form the center joint. The specifications for the binder course call for:

Coarse aggregate retained on 10-mesh sieve	60 to 80%
Sand and material passing 10-mesh sieve	15 to 35%
Asphalt	4 to 6%

The specification for the surfacing mixture calls for:

Retained on 10-mesh sieve	0	to 2	%
Passing 10-mesh, retained on 40-mesh sieve	15	to 35	%
Passing 40-mesh, retained on 80-mesh sieve	25	to 40	%
Passing 80-mesh, retained on 200-mesh sieve	20	to 30	%
Passing 200-mesh sieve	14	to 18	%
Asphalt	9½	to 11½	%

It was found that the asphalt content in the surfacing course could be kept close to the lower limit. In view of recent research this was considered advantageous from the standpoint of stability.

The floor system consists of a 6-in. 1:1½:3 Portland cement concrete slab reinforced with metal trusses 4½ ins. in height, spaced 6 ins. center to center. This rests upon the steel floor beams, which are 3 ft. 10 ins., center to center, spanning longitudinally between the girders, which are 40 ft. between centers. At each girder there is a transverse expansion joint clear through the pavement, with metal guards to which the asphalt surfacing is run. The contractor for the paving work was Francis J. Boas, who sublet the surfacing to the Union Paving Co., of Philadelphia. A. W. Munsell, assistant engineer, Delaware River Bridge Commission, 228 North Delaware ave., Philadelphia, Pa., is the resident engineer in charge of the work.

This bridge is the longest highway suspension span in the world. The bridge carries a central roadway 57 ft. in width, two tracks for car lines and an elevated sidewalk on each side of the roadway. The bridge is being constructed by the Delaware River Bridge Joint Commission of Pennsylvania and New Jersey.

At the present time the longest highway suspension span in the world is that of the Bear Mountain Bridge across the Hudson River, about 50 miles north of New York City. This bridge contains an asphaltic concrete paved roadway 38 ft. in width, with a foot walk on either side.

WIDER HIGHWAYS RECOMMENDED

The immediate adoption of wider highways equipped with modern signal devices was recently urged by the American Road Builders' Association, through its Managing Director, Charles M. Upham, of North Carolina. The immediate incorporation of safety design in roads leading into the larger cities was declared essential to check the appalling loss of life in these suburban districts as a result of automobile accidents.

The new movement in behalf of safety follows a survey on street and highway safety, which brought to light the fact that approximately 24,000 persons were killed and 700,000 injured by automobiles in 1925, with property damages reaching a staggering figure.

"The reports show conclusively that many of these deaths would have been avoided if wider roads had existed, fully equipped with modern signal devices. This is particularly true in the highly populated districts near our large cities," the Managing Director said. "In Chicago and suburbs, alone, approximately a thousand persons were killed last year."

The adoption of wider roads was recommended in a resolution passed by the American Road Builders' Association in convention last January. A complete safety report will be rendered at the next meeting of the delegates to be held during Good Roads Week, January 10 to 15, 1927, at Chicago.

"At that time," said Mr. Upham, "the reports are expected to show that wider and highly signalized roads have been adopted in all parts of the nation."

CAR TRACK PAVING AT SALT LAKE CITY

By P. J. Moran, Commissioner of Streets and Public Improvements, Salt Lake City, Utah

The franchise under which the Utah Light and Traction Co. operates the street railway system in Salt Lake City requires them to pave and maintain their right-of-way on all paved streets. Heretofore the maintenance has consisted mainly of replacing, during the summer, the stone blocks heaved out by frost during the preceding winter.

Early this spring the Commissioner of Streets and Public Improvements made an urgent demand on the traction company to adopt a more satisfactory system of pavement maintenance. Accordingly the railway company has started a system of paving repairs that looks promising. At present they are reconstructing the right-of-way pavement on South Temple, beginning at E Street and running west to Main Street.

The method employed is to first remove the old pavement entirely, after which the track is brought to true alignment and grade. Each tie is provided with a tie plate. These vary in thickness from ½ to 1 in. to accommodate the varying conditions of track grade. All defective portions of the rail are removed, the tie rods cut off, and all joints and seams welded with a carbon arc. Cupped portions of the rail head are also built up by a welding process and then ground down to true surface. An elastic railfiller is then placed on each side of the rails, the entire right-of-way is then brought to finish grade with bituminous concrete well rolled, the rolling being supplemented by tamping near the rails.

The main advantages of this type of pavement along the tracks are: The elastic nature of the railfiller and pavement is expected to eliminate danger of disintegration due to traffic jar, also the waterproof nature of the construction will, to some extent, make the pavement immune to frost action.

It is believed that this type of construction will produce a pavement affording a good riding surface and requiring but little in the way of repairs for many years.

The traction company contemplates reconstructing their pavement on State Street from Fourth to Ninth South Street, according to the same method, immediately after the completion of the work on South Temple, if the South Temple work proves satisfactory.

The company has for this year set aside about $100,000 for this work, which is designataed as extraordinary repairs. The South Temple work will cost about $50,000, or $6.50 per foot of single track.

STANDARDIZATION OF GRADE SEPARATION DESIGN

By C. I. Melick, Bridge Engineer, Michigan State Highway Department, Lansing, Mich.

(From a recent issue of "Michigan Roads and Pavements.")

The grade separation program in

Michigan is rapidly becoming one of our major highway activities. We have but just begun the work of increasing the safety of our highways by protection, separation or elimination of the railroad intersections with our highways. We are all familiar with the absolute inadequacy and feebleness of the little "dollar-sized" unilluminated standard railroad crossing sign in preventing us from crossing the deadly rails before we realize there is anything deadly in the neighborhood.

The monotony of the road, the prevalence of a large number of assorted and not always pertinent signs and the obstructions to vision, together with the universal habit of sitting in the front seat of our motor vehicles and distracting the driver's attention by a constant run of chatter, "talking with the motorman," so to speak, makes life particularly hazardous. At night, when you must in addition perforce strike your own match and hunt for the dollar mark, the operator of a motor vehicle has but a fraction of the protection afforded in daylight.

The flashing signals from powerful lenses operating day and night for any rail traffic within 1,500 ft. of the crossing is not too much for the public to demand at every crossing of railroad with highway. The common requirement of such minimum protection and the standardization of such equipment, which is just as essential as the standardization of the traffic laws, would soon put this equipment on a "Ford" basis, within the limits of the public purse. And, regardless of the cost, how much longer will we continue to set the price of even a single human life at so ridiculously small a figure. A phenomenal public sentiment demanding this protection is predicted for the near future as the least consideration for longer tolerating any grade crossing.

The absolute neglect and disgraceful lack of observance and enforcement of Michigan's so-called "Smooth and Even" grade crossing law is, with the growth in motor vehicle traffic and our stringent elimination of depressions greater than ¼ in. in our pavement construction, creating a further danger and public nuisance with which the public is becoming very impatient, and radical measures are predicted for an early remedy. One of the greatest causes of traffic accidents today arises from some local condition, which if traveled over at fairly slow speed would only jolt and shake us up a bit, but which, when encountered in the course of a concrete pavement which is traveled commonly at 45 miles per hour, would throw the car up in the air and either off of the highway or out of control, at least with inexperienced drivers, who constitute probably 25 percent of all drivers.

Legislation a Remedy

The foolish "jay walking" of some of our highways, crossing and recrossing the railroads so frequently as to suggest that the highway locator was afraid of losing his way unless he tied in to the tracks frequently, must be most searchingly and completely eliminated. Legislation protecting the public from the sins of the past would not be an unreasonable remedy for this evil. The selfish interests of local communities which have sprung up on such improperly located highways must be ignored and publicity directed to offset the natural wish of such communities not to be cut off of the highway. Elimination of such death centers is being given considerable attention by the State Highway Department and such elimination measures are cures and not merely prescriptions, and are usually effected at but little cost.

Under the present laws of this State the railroads do not pay one cent towards this best of all methods of handling the crossing problem, although they are required to pay one-half the cost when elimination by grade separation is resorted to. What a wonderful stimulus to interchange of rights of way, to mutual concessions and the cheapest and best treatment of this problem would be given by a requirement that the railroads bear one-half of such costs and that the items making up these costs be most carefully defined so as to form a business-like working rule for negotiations.

The grade separation is the "solution de luxe," and in the majority of cases perhaps the only real remedy, since there is always a limit to the additional distance one will travel to avoid a danger, and especially so for the American public, which is constantly in search of thrills. A grade separation at its best is not a very desirable piece of our highway system. It always implies a rise and fall hazard. The tendency is to use the maximum gradients and the shortest vertical curves in order to reduce the huge expense to a lesser figure. It always places a limiting restriction on the

sight distance for approaching vehicles. It climaxes the traffic at points where the possibilities for congestion are the greatest and the most hazardous. It always creates a topographic situation which is adverse to the best interests of property frontage. For overhead jobs the public must ride a relatively narrow hogback and for underpasses the drainage conditions are seldom satisfactory. The costs are so great that conditions and facilities provided on the normal section of the highway must be greatly reduced at the grade separations which thus constitute the most hazardous points. The widening provisions for future growth of traffic are by no means so simple or inexpensive as obtains for the widening of the normal road cross-section. And yet with all its faults it is a 100 percent cure for the deadly railroad crossing accidents and fatalities, even at the expense of taking on a tendency toward other hazards which are insignificant in consequence as compared to collision with a railroad locomotive.

Standardization Difficult

Standardization in the design of grade separations is a most difficult, but not an impossible thing, at least as applying to certain features of the design. The greatest hindrance to standardization is the fact that each railroad has its own clearance requirements and design practices, and that the Highway Departments have widely varying sets of requirements and these various idiosyncrasies must each be considered for each individual job. This makes standardization a matter of co-operation. A common ground for design acceptable to all railroads in the state is a necessary precedent to standardization.

The fact that railroads were not laid out on the "rectangular" system, as applies to our highway system, makes practically every railroad crossing a skew crossing and details always will be different for each separation job. In general it is believed that grade separations carrying the highway over the railroad should be of the three-span skeleton type, with the central span designed to provide for two tracks whether the second track exists at the time or not. If no second track is anticipated in the future, the cost of the extra span length used is saved by letting the fill spill past the piers, thus either decreasing the end span or the materials in the wings. The abutment should be of the stub type, with as little material in the wings as possible, since the fill retained is not subject to scour and immersion in water as occurs for bridge structures. The end span should, however, be made a minimum to provide for one track or siding at standard clearances, thus requiring, in case of such increased railroad facilities, only the addition of wings and retaining wall, without interrupting traffic or wasting any part of the structure. The railroads could well agree on standard side and vertical clearances both for permanent and for construction clearances. Permanent clearance heights above top of rail of 18 ft. for interurban roads and of 22 ft. for steam lines should probably be standard and permanent clearance widths of 8 ft. 6 ins. for either traffic from center line of track to face of masonry between top of rail and bridge seat seem adequate. For construction purposes these heights should be cut to 14 ft. and 18 ft., respectively, and widths to 7 ft., except that sheeting for footings might be driven within 5 ft. 6 ins. of center line of track subject to railroad supervision.

All side ditches should be diverted into pipe located in front of the pier adjacent to the track and concrete headwalls provided at inlet and outlet of the ditch and pipe sections and grading carried over same at subgrade elevation and then ballasted to within 2 or 3 ins. of base of rail elevation clear up to the pier. All piers should be protected at each end by heavy concrete bull-nosed pedestals in front of the pier nose, to serve as collision deflectors, since a collision with a slender pier shaft would be disastrous to the entire structure. Piers and superstructures should invariably be of reinforced concrete, since this effects a considerable saving in cost unless the angle of crossing is less than about 45 degs. or more than two tracks are included in a single span, both of which conditions should by all means be avoided by relocation if at all possible, not only because of the saving in cost to be effected, but also because of the lack of rigidity in such structures.

The value of a straight line in highway and railway construction is often overemphasized when these problems are considered. The costs and difficulties and unsatisfactory conditions attending grade separation construction increase very rapidly when angles of less than 45 degs. are encountered.

Widths of Roadways and Walks

The most lively differences of opinion

exist today as to what constitutes an adequate width of roadway and provision for sidewalks on our bridges. This condition is even more nebulous when applied to the requirements of the future. It is certain the requirement for a bridge of sufficient width to permit laying a 20-ft. pavement across it would eliminate practically every bridge put under contract by the state up to about July 1, 1920, so rapidly have our traffic conditions and our conceptions of the future requirements grown. Our standard roadway widths are now 22, 30 and 40 ft. between curbs. Piers should consist of large rectangular spread footings, each supporting a rectangular shaft and each shaft carrying a spread or cantileverd capital and taking its load from a transverse girder, these girders supporting the longitudinal girders or T-beams of the superstructure proper. Base and shaft can be standardized by using one such unit per traffic lane. The transverse girder, which merely equalizes the loads to the deep cantilevered capitals of the shafts can also be standardized for square jobs, but for skew jobs will need special reinforcing if economy is to be observed. Abutments can be similarly standardized for square crossings, but for skew jobs must be given special design consideration.

Superstructures should be so designed that widening may in the future be provided by adding a new traffic lane on either or both sides, although widening on one side only requires the concession of shifting the center line of paving 5 ft. to one side of the existing center line. Symmetry would then indicate either a 22-ft. or a 40-ft. roadway, with no intermediate widths. Transverse girders and shaft cantilevers should be designed for the contingency of supporting sidewalk girders directly on the transverse girders, as there seems to be no way of safely predicting when sidewalk should be provided for. The idea that sidewalks can be cheaply cantilevered from the outside beam is usually erroneous. The cheapest way to carry the walks is by placing an additional longitudinal beam on the outside under the railing. The width of walk heretofore provided has always in the past been 5 ft., but it must be admitted that, however, adequate this may be for the traffic, it looks stunted and stingy when used on a bridge with a 40-ft. roadways, and it is thought that a 6-ft. walk is the least which would be appropriate for such conditions.

The grades up to the structure should be based on a long sight distance and traction consideration given for the heaviest traffic likely ever to use the roads on which the structure is placed, and a 4 percent grade with 200-ft. vertical curve at the top will provide a sight distance of 600 ft., which is considerably greater than the sight distance (530 ft.) corresponding to a 3 percent grade rise and fall over a pavement summit with a 400-ft. vertical curve. Longer vertical curves would be inconsistent and flatter grades are not warranted in comparison with the grades commonly encountered on our heavy-duty paved roads.

Approaches should never be placed on a cruve and deep curb and gutter sections should be provided both for safety and for drainage the full length of the approach grades. Shoulders should be wide enough to permit parking for 10 ft. outside of the road metal proper and should be sodded or surfaced and adequate guard rail furnished. The roadway width inside of curbs should be uniform from end to end of approaches. Superstructure should be of the deck type to permit widening and standardization. Recent tests on bond of concrete to structural rolled shapes indicate that for skews of less than 45 degs. the use of Bethlehem girder sections incased to the bottom flanges and designed as T-beams, including the slab as a part of the beam, may become the most economical type of superstructure, dispensing with flasework, but for the present the reinforced T-beam type proves the more economical.

Desirable Subway Requirements

For subway types of grade separations it is unwise to provide less than the ultimate possible roadway requirements of 40 ft. inside of curbs in a single clear span. Divided roadways but add a serious menace to the safety of traffic, and should not be tolerated in a structure whose sole purpose is to increase the public safety and convenience; a 100 percent job should be made of it. Similarly, every subway should provide sidewalks, since the job is a permanent one, and additional facilities under railroad traffic can only be provided at an expense altogether out of proportion to the value of the improvement, and the resulting job is necessarily a patchwork job and unsightly and not in conformity to a proper development of street properties.

All sidewalks in depressed highways,

such as subways, should be located back from the curb to avoid danger to pedestrians from overhanging loads and to protect pedestrians from slush and water splashed from the roadway. Curb columns provide an admirable means of separating walk from curb, reducing the superstructure spans and providing a support for a concrete splash guard in addition to the curb protection at that part of the structure where slush and water troubles will be most likely to occur. Curbs in these subways should not be less than 10 ins. deep and should provide not less than 9 ins. clear from the column faces. A minimum overhead clearance of 14 ft. should be standardized. There is an indication that 15-ft. clearance is growing in popularity, but with 12 ft. specified as the maximum legal height of a vehicle, the maximum heights using the streets of Chicago reported as 12 ft. 6 ins., and the additional 4 ins. provided in the pavement crown, it is felt that 15 ft. is a little too optimistic a provision for the unknown.

The width of sidewalks is a much discussed question. There is but little doubt that a 5-ft. walk on each side would take all the traffic at any of our grade separations without congestion. When curb columns are used the walks should be lighted and a wide walk in such cases adds to the convenience and safety of the public. It is believed that a walk of 6-ft. width should be standard. This will provide 3 ft. from curb to walk for park space, a 6-ft. walk, and 3 ft. from walk to foot of slope for park space and blind drain or 12-ft. width for walk and park spaces, or a prism section in excavation of 64 ft. width at approximate top of curb level. If the walkway is not needed at once the prism section might be made 46 ft. wide, allowing an 18-in. safety walk along the curb to permit pedestrians to evade the traffic and 18 ins. for sod and blind drains.

If railroads could all agree on a reinforced concrete abutment which provides a single footing for curb columns and abutment wall and concentrate all superstructure loading centrally over this footing, it can be used with great economy, the abutment wall being only 24 ins. thick and the curb columns made monolithic with and portal braced to the abutment wall. Such a structure is now being rapidly completed at Grape, in Monroe county, on Trunk Line No. 65, under the D. & I. Railroad.

The use of a combined footing practiced to some extent with superstructure bearings at curb column and abutment walls is undesirable because of the extreme and rapid shift of footing pressures as heavy concentrations pass successively over the two bearing points. This condition is obviated by the Grape design. It is not believed that it pays to incase the bottom surfaces of the bottom flanges of the steel girders of the superstructure or the outside faces of the girders, but that incasing should be cast to thoroughly incase the insides of girders and the stringers and floor beams, leaving only outside and bottom surfaces to paint. Corrosion of these parts is very slow. If the railroad companies would spread track to 14 ft. centers for this type of structure the girder faces of adjacent girders for double track work would be easily accessible from below for field painting, avoiding the mutilation and weakening of flanges and omission of web stiffeners now so common where 13-ft. centers are maintained.

The painting and cleaning of large flat surfaces is comparatively a very cheap job, and incasement under the circumstances is not warranted. The superstructure of half through type with top flange of girder at elevation of base of rail and incasement extending over top flange to outside face of cover plates is deservedly popular, gives a solid ballasted concrete deck and permits standard track spacing and absolute safety from dragging brake gear or derailments. A safety walk of about 3-ft. width in addition to the 7-ft. clearance from centerline of track is considered essential for the safety of trainmen and passengers. The underpass, which has to be drained artificially by automatic pumping, is rapidly becoming a workable and satisfactory type. Provision for heating inlet drain castings to make positive drainage into the pump pit during icy conditions of the pavement will greatly aid in making this type satisfactory. Considerable progress is anticipated during the coming season in the process of standardization of design for grade separations.

ALL-AMERICAN SHIP CANAL

The sharp divergence of opinion that exists today (regarding an all-American ship canal), even among those presumably best informed, indicates the extreme complexity of the problem and

the far from complete stage to which impartial investigation has been carried. Unfortunately, there is a disposition on the part of the more enthusiastic supporters of the scheme to yield to the imaginative appeal that a great engineering project invariably produces.

The development of modern rail and highway transportation of steam and electric driven trains and motor trucks with ever-increasing speed and efficiency has apparently relegated the canal to the past. Abandoned or little used waterways all over the country point to this fact. It would be sheer waste to add to the many millions now sunk in such projects without a most thorough study of comparative transportation costs and service, and particularly to embark on a program of vast expenditure under the influence of sentimental enthusiasm or political pressure.—From the Philadelphia Inquirer.

STREAM POLLUTION STUDIES IN MARYLAND

By Abel Wolman, Chief Engineer, Bureau of Sanitary Engineering, Maryland State Board of Health

(Editor's Note: The following information is from the 1925 report of Mr. Wolman.)

As in the past, this Bureau, in 1925, received a number of complaints relative to high fish mortalities. These complaints were from Curtis Bay, Back River, Westminster and other areas.

A number of fish had been killed in Town Branch, near Westminster. From our investigation the following causes were probably responsible: The small flow of Town Branch during a prolonged drought; further depletion of the waters of this stream by the diversion of Hull Creek water through the Westminster filtration plant; the exceptionally high temperatures during the period when fish were reported dying in other streams of the State; the normal sewage pollution of Town Branch, and the discharge of pea canning wastes into this stream, which probably depleted further the oxygen content of the water.

High fish mortality in Back River at the same time as in Curtis Bay and Town Branch indicated that the excessive heat at this time may have been partially responsible for this temporary condition. The Back River water, however, was acid at the western shore near the Eastern Avenue Bridge. This reaction also prevailed upstream towards the Eastern Rolling Mills, which industry is known to have discharged acid wastes. The river water was apparently normal in appearance and reaction at the eastern shore near the same bridge. This point is upstream from the discharge conduits of the Baltimore Sewage Treatment Works. The Eastern Rolling Mills is now conducting experiments to reduce the amount of acid wastes in its effluent.

Excessive fish mortality in the Curtis Bay area occurred at two distinct times. The first difficulty was found to exist in June when complaints were received from other areas. Nothing especially significant could be learned other than the possible detrimental effect of the prevailing high temperatures upon fish life.

When the second fish mortality occurred in this same area nothing unusual was found which could be considered directly responsible. The industrial plants seemed to be functioning normally in so far as the discharge of their wastes was concerned. It is possible, however, that an accidental break in the "molasses slop" line at the U. S. Industrial Chemical Company's plant, which had occurred a few days previous to this investigation may have been partially responsible for the probable depletion of the oxygen content of the Curtis Bay waters, with the consequent death of many fish.

During the past year, there were a large number of new stream pollution cases brought to the attention of this bureau. In addition to investigating these, our activities were continued on those studies begun during the previous year or two. One of the more important of these was the study of the wastes from the plant of the Congoleum-Nairn, Incorporated, located at Asbestos, Carroll County. Our studies were begun in 1923 and were first carried through on a laboratory scale, with the ultimate recommendation that the waste should be treated with alum at the rate of 12 grains per gallon followed by sedimentation for at least one-half hour. In order to confirm the practicability of this procedure, an experimental plant was built at the factory site so that the waste liquor could be treated under actual operating conditions. This experimental plant was of such capacity as to allow the treatment of from 32 to 60 gals. of waste per minute. The experiments conducted covered a considerable period of time beginning in March and ending in October, 1925. Twelve and 15 grains of

alum per gallon were used and intermittent and continuous operation of the settling tank with variations of from 1 to 2 hours sedimentation were tested. A large number of samples were taken for analyses. As a result of this work it was apparent that 15 grains of alum per gallon on the intermittent operation basis produced the best results with respect to the turbidity and suspended solid content of the final effluent. Additional studies may be made with iron and lime before the plant treatment unit is installed, as the company officials have expressed their desire to conduct these further experiments.

Other stream pollution cases receiving the attention of this Bureau resulted from the discharge of wastes from canneries, creameries, laundries, a pigment manufacturing plant, a steel rolling mill and a garbage works.

Perhaps the most important of these are the wastes from the Sanitary Reduction Company's garbage works at Bodkin Point, where the garbage from Baltimore City is treated. Here water pollution and an aerial nuisance existed. In connection with the former, a number of experiments were conducted by the company's chemical engineer, to learn the proper method of treating the liquid wastes from the grease separators. It was found that plain sedimentation with 24 hours subsidence would remove a large amount of the solids and grease formerly discharged into Bodkin Creek. As a result of this experimental work, two new 60,000 gal. tanks have been installed for the removal of the settleable solids and grease.

These tanks operate on a fill and draw basis and the company's engineer states that they remove daily an average of four tons of dry material and two barrels of grease.

The following tabulation indicates the efficiency of the new tanks, based upon representative 24-hour composite samples.

EFFICIENCY OF GREASE SEPARATOR SETTLING TANK

Station	Total Solids	Suspended Solids	Grease
Influent, p.p.m.	117,105	22,500	12,622
Effluent, p.p.m.	3,832	860	3,218
Percent Removal	96.73	96.18	74.50

A second source of stream pollution is the waste removed by the scrubbers which wash the dryer gases. After using two small settling tanks in parallel to treat this waste, a new concrete basin was built and put in series with the small tanks. This treatment effects about one hour subsidence and materially reduces the suspended solids discharged in the scrubber liquor.

The general sanitary conditions around the garbage reduction works have been materially improved. These improvements include the covering and seeding of the grease lagoon, with the elimination of the seepage of grease from it; the removal of all waste from the plant site and the spraying of all places where there is a possibility of fly breeding. Sodium arsenate and dilute sulphuric acid have been used for this purpose. The work accomplished during the past year leaves two major problems unsolved, namely, the more complete removal of solids and grease from the waste liquors and the prevention of grease drainage from the scows. The studies on the former of these problems will be continued and the cooperation of the City of Baltimore in properly altering the scows, so as to overcome the difficulty mentioned above, as well as to prevent the spillage of garbage, has been obtained through conferences with city officials. Efforts have been made by the city officials to prevent the breeding of flies in the garbage on the scow during transportation.

At St. Helena, it was alleged that the Glidden Company was polluting Colgate Creek. This plant is located opposite River View Park. The product manufactured is an artificial white lead known as "lithopone." The process consists of mixing, grinding, pulverizing and fusing coke and barium ore. The fused product is mixed with water and settled. The settled material is one form of waste. The solution then passes to mixing tanks where zinc sulphate is added. The combined product is "lithopone." Some of this material is lost in the process and has been discharged into Colgate Creek. In the production of zinc sulphate, iron and manganese oxides are precipitated. These have been discharged into Colgate Creek. As a result of the activities of this Bureau, the waste which formerly discharged into the lagoon receives additional treatment so as to reduce its water content. This minimizes the possibility of break in the bulkhead and consequently allows the discharge of little, if any, of this material into the creek. A new settling tank and a new filter have been installed,

resulting in the reclaiming of some of the "lithopone," which was formerly lost, thereby improving the nature of the liquid waste from the "lithopone" buildings. It should be mentioned, however, that the company's officials had planned the use of the new filter before this Bureau began its investigation. Lastly, the iron and manganese oxides are no longer discharged into Colgate Creek, but are placed in the lagoon where they seem to be retained satisfactorily.

The study of creamery wastes at Cecilton, Rising Sun and Detour was begun in 1924. At the first of these, it was found advisable to forego the recommendations as to acid arising. As an alternative, tentative approval was given to certain procedures which would lead to the production of a clean ditch into which the wastes are discharged. In addition, the whey from the skimming tank is to be placed in a secondary tank and not on the floor, thereby eliminating this waste from the ditch. When possible, additional amounts of water, beyond that required for ordinary plant operation, will be pumped into the ditch so as to maintain a good scouring flow in it during the day.

At Detour, the milk wastes from the cooling station of the Fairfield Farms, Incorporated, were satisfactorily handled by extending the pipe line into the center of Double Pipe Creek and so placing it as to obtain the maximum dilution effect of the stream upon the waste liquors.

The other creamery waste receiving the attention of this Bureau during the past year was that from the Sheffield Farms Company at Rising Sun. Although our studies in 1924 indicated the necessity for acid treatment with hydrogen ion control, when this plant was operated as a condensary, the wastes now discharged are materially changed. The Sheffield Farms Company no longer condenses milk, but simply cools, pasteurizes and bottles it. Under these conditions the stream will care for the wastes, if it is flushed occasionally by the water in the dam used by this company for condensing purposes.

There still remains a problem of stream pollution at Rising Sun. This is due to the wastes from the canning factory owned by the Cecil Canneries, Incorporated. At this plant corn only is canned for a period of approximately six weeks during the summer, Through the activities of this Bureau, a screening plant was installed. This resulted in removing a considerable proportion of the floating particles formerly discharged into the stream from which the Sheffield Farm Company obtains water for condensing purposes. Although some of the solids are removed from the canning factory waste a profuse of fungus, resembling leptomitus, appeared on the ammonia coils at the Sheffield Farms Company's plant. As the manager of the Cecil Canneries, Incorporated, seemed desirous of trying sterilization of the screened plant effluent to overcome the fungus growth it did not seem advisable to object to this procedure, although we have no evidence that the fungus growth can be prevented by chlorinating the cannery wastes.

A number of other canning factory investigations included plants located at Westminster, New Windsor, Crisfield, Cambridge, and Perry Point. In practically all of these cases some cause for complaint existed but the best method of treating the various types of canning factory wastes have not yet been made available. Temporary methods of partially treating these wastes were suggested. In all cases every effort is made to keep as much putrescible material from the streams as possible.

Steps have been taken by this Bureau to obtain the cooperation of the Maryland Canners Association on experiments leading to a solution of the problem of canning factory waste treatment.

Miscellaneous types of wastes were investigated. At Franklintown a laundry was discharging into Franklin Run, producing an unsightly condition on the banks above and below the outlet. This problem requires further study. At Elk Mills large amounts of waste dye liquors were being discharged into Big Elk Creek, the source of drinking water for Elkton. A diversion dam was built to retain the solid material flushed out at times of high rains. Such a procedure is not entirely satisfactory to this Bureau, but no further action is anticipated until a nuisance results.

An inspection of the Little Gunpowder River near White Hall, following a complaint relative to the creation of a nuisance by the discharge of paper mill wastes, showed that no objectionable conditions existed at the time of the inspection and only infrequent discharges of small quantities of waste occurred.

A study of the acid wastes from the Eastern Rolling Mills discharged into

Back River was begun more than a year ago. As no action had been taken by the officials of this company, the question of the treatment of pickling liquors was again brought to their attention. In December, 1925, arrangements were made to have experimental studies carried on in the company's laboratory to develop methods of treatment for the elimination of the discharge of sulphuric acid and ferrous sulphate.

A LONG WELDED PIPE LINE

By B. S. Havens, Schenectady, N. Y.

What is said to be the first completely welded pipe line in this country and the longest pipe line of its type, was recently completed for the city of Vallejo, California. This pipe line has a length of 22 miles and was built for the transmission of Fleming Hill reservoir, just north of Vallejo.

The city of Vallejo is situated in Solano County, California, near the head of San Pablo bay, on the east shore of Mare Island Strait. It has a population of 26,0000. The water supply is municipally owned and is secured from storage reservoirs in Wild Horse Valley, about 14 miles northeast of the city.

The growth of the city as well as the increasing demand of the Mare Island navy yard (supplied by the municipal system) made it necessary to increase the water supply materially. As a result, it was decided to develop the Gordon Valley project, involving the creation of a storage reservoir in Gordon Valley at a point about 26 miles northeast of the city, and the installation of a pipe line to the city to connect with the existing municipal distributing system, a total distance of approximately 22 miles.

The pipe line is of steel-plate construction, all seams being electric-arc welded. The pipe is 22 and 24 in. in diameter, 15 miles being 24-in. and 7 miles, 22-in. pipe. Of the 24-in. pipe there are approximately 11 miles having a wall thickness of 3/16-in. and 4 miles of ¼-in. material, whereas the 22-in. diameter pipe has a wall thickness of 3/16-in.

The complete pipe line was built by the Western Pipe and Steel Company, using General Electric welding machinery. The total static head on the pipe varies from 100 to 400 ft, and all of the pipe was tested at the shop to 225 lbs. pressure. A number of sections were tested to 325 lbs. and a few to 720 lbs. pressure but no leaks developed in the welded seam.

Automatic electric arc welding was used at the factory for making longitudinal seams for 14-ft. sections of pipe. Two of these sections were joined together by means of a circular weld using semi-automatic equipment. The 28-ft. sections were delivered in the field and several sections were welded together on the surface by hand welding before being lowered into the ditch.

The finished 22 miles of pipe was put under final test for 48 consecutive hours in the early part of March of this year. During this length of time the pipe was held under a press pressure of 200 lbs. per sq. in. at the lowest point in the line, and was found to be absolutely free from leaks. During the 48 hours of test the line was continuously patrolled and inspected at all points but no leakage was discovered.

During the time of filling the line, but one leak occurred in the straight seam in the entire length. Nineteen girth seams showed leakage or sweats out of a total of 8,200 girth seams in the entire length. Of this total, 4,100 were field joints, hand welded, and with semi-automatic welding equipment. The field welding equipment used consisted of several gas engine driven, General Electric welding generators.

Following the final tests and inspection, the pipe was officially accepted by the city of Vallejo on April 2.

EXPERIENCE WITH LIME IN BUILDING CONSTRUCTION

By J. P. Mollenkof, Superintendent of Construction, John H. McClatchy Co., Philadelphia, Pa.

(A paper read at Eighth Annual Convention, National Lime Association, June 8-11, 1926, at French Lick, Ind.)

I have been wondering how you persuaded me to come here to try and tell you something about lime. I do not understand why you did not select someone who knows lime. First of all, I want it understood that I am not connected with any lime company and that the only reason I am using lime is simply because I want to use materials that are best and which I can buy at a price which will enable me to compete with other contractors.

The reason I have selected lime may be because my grandfather used it for mortar in building church steeples, and

for stucco 75 years ago around Philadelphia and the jobs are still standing. My father also used straight lime in all his plaster and stucco 45 to 50 years ago and his jobs are still in good shape. Possibly their reason for using lime was that they had no other choice, as cement was out of the question in those days. However, when I can look back and see jobs standing for 75 years and more I often wonder why builders waste their time and money experimenting with every new material that comes along, pushed by a smooth tongued salesman without any practical experience.

Some 12 to 15 years ago I started a collection of old stuccos and plasters, getting complete information as to how old they were, nature of aggregate, etc., etc. I now have specimens of stuccos, mortars and plasters dating back over 100 years. Quite a number of these specimens were plastered on hand split lath, fastened with hand made nails. When these specimens were taken they were as good as the day they were put on. They are all examples of lime plaster, well sanded.

The organization with which I am connected, John H. McClatchy of Philadelphia, has always been interested in giving the people the most satisfactory home that can be built for the price involved. This has, of course, necessitated considerable experimental work on our part in an endeavor to determine what materials were most suitable from the economical point of view, as well as the standpoint of durability. For stucco, plaster and mortar we have confirmed the fact that lime was the most satisfactory. In addition we have found that this material also served a useful purpose in precast work, and have made use of it accordingly.

Some six years ago the speaker was working with various concrete products. About that time we had considerable trouble with the stucco then being applied by various contractors. There seemed to be some difficulty in securing uniform and satisfactory results. It occurred to us that perhaps we could solve the problem by using a mortar mixer and deliver the stucco to the job ready-mixed. We tried it, and the indications were favorable. However, the mix then used did not seem to us to be the most suitable and we began to study the problem more intensively. While this study was under way with stucco we commenced to have some difficulty with plastering, which was then done by subcontractors, and it also seemed a good plan to consider the problem of masons mortar. The problem grew rapidly once we started.

We tried practically every plastering material that was available. Some were hard to work but set quickly. Some made a very easy working mix, but cut down the strength. Others gave high strength, but were hard to handle. We finally adopted lime and since then we have had practically no difficulty in securing satisfactory and durable construction.

We decided to build a central mixing plant, and had to do it in a hurry, for the jobs were waiting for material. This was done. We installed a slaking system, consisting of a large slaking box about 30 ft. long, 6 ft. wide and 2 ft. deep, in which a man can run off 120 bushels of lime per day without trouble. On the job we found that thout 60 bushels was an average good day's work. With the large box we have our water readily available, four 1½-in. streams discharging into the box as needed. The the slaker can shovel it in without much effort and can handle the job without lost motion. From the box the lime is run through a screen into storage vats where it is allowed to stand until cold, a matter of three weeks under normal conditions. These vats are about 30 ft. long, 5 ft. 6 in. deep and 5 ft. wide. After the lime is run off it is allowed to stand for two days and the water which rises is then pumped to a storage tank, to be used in slaking another batch of lime. The putty then lies for the balance of the three weeks without being disturbed.

From the vats the putty is moved to a mixer by wheelbarrow. We have found by experience that it does not pay us to try and pump the lime from the vats to the mixers. Two Blystone mixers are used, each arranged for independent operation, with separate sand storage bins, etc. The mixer is fully charged with sand while in motion, the necessary amount of properly picked hair and fibre put in, the lime added, and the whole mass is then thoroughly mixed for about 3 minutes. The mixer then turns over and discharges into a waiting truck below. Four men operate the mortar plant, taking care of the slaking, moving of the lime to the mixers, sand storage, the mixing, hair and fibre picking and general work with a

production of about 65 tons per day. This plant runs steadily every working day in the year. In fact, it is the only way that we can handle plaster and stucco jobs during the cold months. Construction naturally slows down to some extent, but even during the coldest weather we slake at least 60 bushels of lime every day. In fact, three years ago we lost only two days in zero weather, about one week was lost the year before last, and about the same time was lost last winter. We tried mixing on the job, but that did not work, and since we have been using the mixing plant everything has been much more satisfactory. We do not have trouble with waste or frozen plaster and we find that the work goes faster on the job. During the warm months we slake on an average of 150 bushels of lime per day, so you see that our central mixing plant is a busy place at all seasons of the year.

Within a 5-mile radius of our plant we find that we can get ready-mixed plaster, and stucco on the job at a lower cost than can possibly be secured by even the most efficient field operation. We have far less waste and are assured of a uniform mortar at all times. It also increases the efficiency of the plasterers, for they know exactly what kind of material to expect, and steadily, not having to bother about retempering or other delays which are frequently encountered when field mixing is practiced.

For delivering mortar we use International trucks, with 1 yd. special bodies designed to dump into mortar boxes. We found that puncture proof tires, either of the solid or perforated type, are absolutely necessary, for tire trouble must be eliminated.

The way to make the best stucco was our first problem after the central mixing plant had been developed. This involved a careful study of the materials available. We studied lime, cement, sand and special aggregates. We finally developed a specification which we thought was suitable and then the problem was to get sand which closely approached this specification, for it was, of course, impossible to get sand commerically that would meet every requirement and still be cheap enough to use. We have standardized on a local sand with satisfactory results. This we use for the first two coats. We purchase in large quantities and are able to get an attractive price because the dealer knows exactly how long it will take his trucks to bring a load to the plant and also that our storage is large enough to take sand at his convenience.

The common sand we use is the finer material from concrete sand, the largest particles passing a No. 8 screen and about 5% passing a 200-mesh screen. The approach to our plant is paved and this eliminates the danger of trucks getting stuck in the mud, which is a serious item in trucking costs. Naturally we benefit by the facility, which is not usually the case with sand deliveries direct to a housing operation.

Sand is used only in the scratch and brown coats of our stucco, as we find that a coarser material works better with the type of finish we use. For this finish coat we prepare our own aggregate by crushing Cape May pebbles, or "pea grit." These pebbles are extremely hard and break up very well in a roll crusher, set to ¼ in. There is a surprisingly small percentage of fines in this crushing and we have found by experience that screening is not necessary. This aggregate is very light in color and blends in with any of the colors we use to good advantage.

We always secure our stocks in large quantities. This applies to all materials used, and as a result we get a good choice. This is particularly true with respect to hair and fibre, which are important in both plaster and stucco. We use equal parts of hair and fibre, running from ½ to 1½ in. long and the fibre from 2 to 3 in. in length. Both materials go through a picker which fluffs them up ready for use. The picking is done by the mixer operator in his spare time.

All our plant proportions are by volume, as we have found that method of proportioning to be the most satisfactory. For the scratch coat stucco, we use a mix of about 2½ cu. ft. of lime putty, 1 sack of Portland cement and 8 cu. ft. of sand, to which we add 1½ lbs. of hair and 1½ lbs. of fibre. For the brown coat, which must be leaner, we use 2 cu. ft. of lime putty, 1 sack of Portland cement, and 8 cu. ft. of sand. We find that in stucco it is not necessary to add any hair or fibre to the brown coat. In the finish coat we use 2 cu. ft. of lime putty, 1 sack of Portland cement and 8 cu. ft. of crushed aggregate, without any hair or fibre.

A great deal of our stucco is applied over frame construction. On this type of house the frame is first covered with

a layer of rubberoid, which we have found to be better than the ordinary building paper which is usually applied. Over this, galvanized wire is applied, furred out with wood lath on 12 in. centers. This ensures a good thick coat of stucco, protecting the metal and eliminating cracks.

When we apply the stucco to concrete blocks it is highly important that the surface be wet first. After the scratched coat is applied we let it harden and dry for at least two days. If the scratch coat has been put on frame construction it is not necessary to dampen it before browning, but if it is on blocks, we find that it must be wet before the brown coat can be applied. This is because of the high absorption of the blocks.

The brown coat is applied to bring the surface out and even up the job. Before it has hardened, the finish coat is put on and worked into the brown. The finish most commonly used is a rough drag or scrape finish, as will be seen from the pictures, made by dragging the edge of the trowel over the surface. This work is done by the average plasterer without special training and gives very satisfactory results. We use cream, salmon, buff and grey tints in addition to the pure white. For the tints, mineral colors (oxides) are used, and for the pure white we use white cement instead of the grey cement ordinarily used.

The story of our plaster is quite similar to that of the stucco, except that we use slightly different proportions. Both metal and wood lath are used in our houses, the wood usually on the side walls and the metal on the ceilings. We have found it more economical to use a stiff lath—about 3.2 lbs. per sq. yd.—for ceiling work, than to use the lighter grades. The reason is that there is less dropping and the men can work faster over a stiff surface. We have never had any trouble from plaster falling from either ceilings or walls.

For the scratch coat our mix is: 8 cu. ft. of sand, ½ sack of Portland cement and 4 cu. ft. of lime putty and 3 lbs. hair and fibre, or a 1:2 mix.

The brown coat mix is: 8 cu. ft. of sand, ½ sack of Portland cement, and 2 cu. ft. of lime putty and 1 lb. of hair, or a 1:3:2 mix.

All our plaster work is doubled-up, or laid-off. That is, the brown coat is applied immediately after the scratch coat, thus ensuring an absolute bond between the two coats. We use a different mix for the two coats in order to reduce cracking and also to reduce the cost, but feel that a rather rich scratch is necessary, for upon it depends the integrity of the whole job. However, we do not find it necessary to get a special class of plasterers for this work, as we find that with lime mortar such as we supply to the plasterers there is no difficulty in securing good work, with the proper supervision. Their work as well as the material is uniform, and we find the same kind of plastering is done in the afternoon as in the morning. The mortar is always smooth, uniform and easy working and does not "pull their arms out." Every man covers a good yardage each day and we use a high percentage of apprentices. We secure good plastering and are not troubled with falling ceilings, bulged side walls, or cracking.

We have had complaints at various times from some plasterers about the use of machine made mortar. Some of them claim that they get a better and harder wall when the mortar is prepared on the job, but we have found that the machine made mortar is more satisfactory, both as regards durability and economy. It has been necessary to clean house a couple of times with both the plasterers and the hod carriers, but we have never experienced any difficulty in getting men to take the place of those who were discharged, as we give them steady work practically the whole year round. At one time we discharged 65 plasterers and filled their places within a few days.

When one considers that for the past four years Mr. McClatchy has been building about two houses every working day or between 600 and 800 per year—you will realize the problem that must be met in supplying the men with mortar for plaster and stucco. At times well over a hundred plasterers are on the various jobs, and never less than 40 plasterers are working.

At first we supplied the brick and stone masons with their mortar, but we found that it was more satisfactory for our central plant just to supply the plasterers, where a high grade mortar is absolutely essential, than to attempt also to make the leaner mortar used by the masons. In an emergency, of course, where a small amount is required, we send mortar out to any part of the job, made as needed for the work under way.

We have found that lime stucco and lime plaster are very adaptable. They are easily prepared, easily worked, easily

colored. Any desired texture may be secured without difficulty, ranging from the smooth finish to special trowel finishes and color blends. The stucco we use can be made up in any conceivable fashion. The Home Electric, which we built for the Sesqui-Centennial at Philadelphia is a lime stucco job, finished with three color Spanish style stucco. The only change in our specification was in the colors used and in the special trowel work on the surface. Those of you who plan to be in Philadelphia can see thousands of lime jobs in good condition.

ECONOMICS OF HIGHWAY TRANSPORTATION

By Henry R. Trumbower, Economist, U. S. Bureau of Public Roads, Washington, D. C.

(A paper read at the Annual Convention of the Western Society of Engineers, Chicago, on April 22, 1926.)

The important types of land transportation are steam and electric railway transportation and motor vehicle transportation over the highways. Highway transportation is the older type. In the early days of this country the people were wholly dependent upon the transportation afforded by the highway and upon water transportation, inland and coastal. When canals made their appearance it was believed by many that the canal and the highway should be and remain the principal means of transportation for many years to come. It is now almost a hundred years since the first steps were taken along the lines of railroad development. The venture proved such a success that it was not long before those who had vision could see that both the canal and the highway were doomed as the agencies involving the transportation of persons and property for long distances. The canal dwindled in importance and finally its use reached the stage where the canal could no longer be considered as an important factor in our transportation economy. In most cases the canals were abandoned and allowed to go into decay.

The advent of the railroad also checked the relative importance of the highway. To be sure, the highway did not go the way of the canal, but its significance as a long distance carrier waned so that it was not regarded as being more than a local transportation agency. The highway had been looked upon as a necessary feeder to the canal. When the railroads were built they supplemented the canal and so the highway was properly regarded as the necessary feeder to the rail lines. Local travel between towns and cities only a short distance apart still sought the highways—though after the advent of the electric railway and the electric interurban lines much of this so-called suburban and interurban business was diverted from the highway, also a part from the steam railroad, to the electric lines which were capable of conducting both a passenger and a freight business.

Relation Between Railway and Highway

In discussing the relation between the railway and the highway in this country and in England a noted English economist pointed out this essential difference. In England practically all the highways had been developed and built prior to the time of the advent of the railroad; in this country, except in the old and well settled sections of the eastern States, the railroads came first and highways were later laid out and built leading off in most cases from points on the railroads to the interior country. Except for the eastern section of the country highway transportation for the most part did not assume any of the long distance aspects which characterized the English and continental systems of highway transportation. The railroad developments and extensions to a large extent became the determining factors as to the settlement of the people and the development of industries and commerce. Sections of the country without railroad facilities were slow to be developed and settled in that population tended to follow the construction and extension of railroad lines.

This condition where the railroad was the main agency of land transportation continued to exist till shortly after the beginning of the present century. If it had not been for the invention, development and extended use of the motor vehicle, our highways would not now occupy a much changed position in our economic life than they did during the greater part of the last century. The advent of the automobile created a new demand for the use of our roads, in that it was capable of being operated longer distances than the horse drawn vehicle and thus afforded more service. Thus a new use and a new service was furnished by the existing highways. Today instead of being a secondary transportation agency and of serving as feeders to

the railroads, the highways in connection with the use of the motor vehicle furnish us with one of our main and most important agencies used in the transportation of persons and goods from place to place.

Investment in Highway Transportation

The highway transportation system and equipment, which includes the vehicles as well as the roads, involves an investment of approximately $26,500,000.000. This amount can be compared with a total steam railroad investment of about $22,000,000,000. The street railways and interurban lines represent an investment which in 1922, according to the census reports, amounted to about $5,000,000,000. In short, we are justified in saying that the country's investment in highway transportation equals very closely the reported investment of $27,000,000,000 in all steam railroad and electric railway property in the United States. The figures used in connection with these railroad investments are based on government reports and on census figures. The highway and motor vehicle figures can at the best be but an estimate based on the knowledge we have of the number of motor vehicles in use and of the amount and character and costs of improved highway mileage of the country.

At the end of 1925 there were 20,051,276 motor vehicles in use in the United States; 17,597,702, or about 88 per cent were passenger cars, and 2,453,574, or 12 per cent, were classified as trucks. The investment in these vehicles can be estimated as amounting to $18,551,934,832. This estimate is based upon an average cost of $866 per passenger car and an average cost of $1,350 per truck which were the actual average retail selling price in 1925. To arrive at the total investment it does not appear unreasonable to use these figures and apply them to the total number of vehicles in use. As a matter of fact this estimate is rather conservative in that the average selling price of motor vehicles has been on the decline since the year 1920, when the peak of average prices was reached. The prices between 1918 and 1920 were also higher than the 1925 average. To say, therefore, that the passenger cars and trucks used at the present time cost the people of the country 18½ billion dollars is putting this investment at a minimum figure. The road or highway surfacing, as it exists today, not including any expenditures for city streets and omitting any right of way values, may be estimated as representing an investment of about 8 billion dollars. The per capita investment in motor vehicles, according to these estimtes, amounts to $161; the per capita investment in improved highways $69; the total investment in highway transportation of $230 per capita as compared with the investment in all the steam railroads and street railways about $235 per capita. The country's total investment in railroads, steam and electric, and in highway transportation amounts to about 53 billion dollars. This is only one billion dollars less than the total value of all the farm land in the United States according to the 1920 census. Reduced to a per capita basis, the average investment in railway and highway transportation facilities amounts to about $465 per capita.

This transportation property and equipment is all privately owned and operated with the exception of the highways which are built and maintained at public expense. This is our big experiment in public ownership. These investments in transportation agencies are owned, 15 per cent by the public and 85 per cent by private individuals and corporations. The corporate ownership field is largely restricted to the steam and electric railways; the motor vehicle are all privately owned and operated except for small number of vehicles owned and operated by corporations engaged in furnishing some form of common carrier service.

Horse Drawn Vehicles

In order to have a complete picture of highway transportation mention should be made of horse drawn vehicles. The traffic counts which have been made recently show that the horse and wagon have almost wholly disappeared from the main travelled rural highways. The horse and buggy are rarely seen; horses used in transporting heavy loads are still encountered from time to time drawing agricultural products from the farm to the market. But even here the motor truck is rapidly taking the place of wagon hauling. Although the production of the principal crops of the United States increased 13 per cent from 1900 to 1924, the number of horses on farms was approximately the same in 1924 as in 1900. The following tabulation shows this change in the number of horses found on farms:

1900	18,267,020
1910	19,833,113

1920	19,767,161
1923	18,627,000
1924	18,263,000

Horses, other than those on farms, decreased in number very much more: in 1900 there were 2,936,881 horses in this class and in 1910 the number had risen to 3,182,789; by 1920 it had gone back to 1,705,611. Since 1900 the number of horses in cities and towns had fallen so that in 1920 there were 58 per cent of the number of horses found in 1900. The use of the horse naturally decreased much more in the cities than it did on farms. Although tractors are used to a considerable extent on the farms, there still are a great many farming operations which are carried on with horses. much of the farmer's road work, however, is now done by motor vehicle. The large number of automobiles registered in the strictly agricultural states tends to prove this.

Motor Truck Saves Time in Haulage

With the increase in wages paid to hired men and the added difficulty of securing and retaining farm labor the use of the truck in hauling agricultural products from the farm to the market has become important. The deciding factor is the saving in time which the motor truck makes possible and also the greater operating radius of the motor vehicle. An investigation of the elapsed time consumed by using horses and wagons and motor trucks showed that it took a horse drawn wagon 7.5 hours to make a round trip from farm to market a distance of 10-11 miles; with motor truck it took only 2.4 hours to make a round trip. The motor truck did the same amount of haulage in one-third of the time. Another observation showed that for an 18-19 mile trip it took 11.2 hours to make the round trip with horse and wagon and only 4.1 hours to make it by motor truck. The saving in time in this case was 6.1 hours and the time consumed by motor truck was only 36 per cent as great as that consumed with horse and wagon. Economies of time of this nature tend more and more to promote the use of the motor truck for hauling products by the farmers. The investigation based on a number of observations showed that it requires approximately one-third as long to make the average round trip with a truck as it does with a horse drawn vehicle and if the same size loads are hauled with trucks as with wagons the time required per ton mile will be practically one-third as much with truck as with wagon.

Horse Drawn Vehicle Practically Gone from Highway

The traffic counts taken on state highways of Massachusetts show what the tendency has been with reference to horse drawn vehicles. The percentages of horse drawn traffic are set forth in the following tabulation:

	Per cent
1909	58
1912	33
1915	17
1918	6
1921	2½
1924	0

According to this it would appear that in Massachusetts, and there must be many states in which similar conditions prevail, the horse drawn vehicle has practically disappeared from the main rural highways. In Louisiana a traffic census, taken in the summer of 1925, showed that the motor vehicle on the highways was 95.2 per cent and the horse drawn traffic was 4.8 per cent. It is not believed that there are many states which exceed this ratio of horse drawn traffic to the total. In some of the larger cities a considerable number of horse drawn trucks are still found in use in the more congested sections. On account of such congestion and of the resulting inability to use motor trucks in the most efficient manner possible this horse drawn traffic continues to exist in spite of the theoretical savings which can be calculated for motor trucks. The sections of New York and Chicago in and about the large railroad freight terminal are good examples of areas in which there is a continued use of horses in trucking service.

Passenger Carrying Capacity of Motor Vehicles

Another interesting question is the ability of the motor vehicles of the country operated over the country's highways to serve the people. These 20,051,276 motor vehicles, passenger cars and trucks, are in operation and capable of operating over all of the streets of our cities and over 2,976,887 miles of rural highways in the United States. The problem of congestion of street and highway traffic arises out of the uneven distribution of traffic over the existing street and highway mileage. Certain streets in cities are obliged to carry more than their proportionate share of the traffic; likewise in the country the so-

called main or trunk roads carry the preponderant share of the traffic. According to the traffic surveys which have been made it is shown that about 10 per cent of a state's highway mileage carries approximately 50 per cent of the motor vehicle traffic.

The highways of the country have become, in a sense, the primary passenger carrier transportation agency and the steam railroads still remain the principal freight carriers. The 17,597,702 passenger motor vehicles, based upon an average capacity of 4 persons per car, represent a total passenger carrying capaicty of 70,390,808 persons. More than half the country total population can be carried at one and the same time by the existing number of passenger automobiles. If we assume that each of these passenger cars are operated an average of 5,000 miles a year and that 2½ passengers are the average number of passengers carried per car, we arrive at a total passenger automobile mileage of 219,971,727,000 miles. A large part of this passenger mileage is produced wholly over city and town streets. Facts have not yet been developed which show accurately what proportion of this estimated passenger mileage is produced on rural highways and what part is to be credited to city streets. An estimate that one-half of the total passenger car mileage is found on the rural highways appears, however, to be conservative from every point of view. If we make this apportionment we arrive at a figure of 109,985,636,000 passenger miles as the annual passenger mileage carried by the highways of the country. In 1925 it is reported by the Interstate Commerce Commission that the total passenger mileage of Class I railroads amounted to 35,963,862,000 passenger miles. It is, therefore, safe to estimate that automobiles of the country carry approximately three times as many passengers one mile over the rural highways as the steam railroads carry.

The electric railways are said to produce about 13,000,000,000 passenger miles. When these are added to the passenger mileage of the steam railroads, we get a total of 48,963,862,000 passenger miles produced by automobiles over both city streets and rural highways. This demonstrates clearly that the automobile is our principal passenger carrier.

The passenger carrying capacity of the railroads is limited to 41,399 passenger cars and coaches with a total capacity of 2,612,056 passengers. The passenger carrying capacity of the automobiles is 60,390,808, or almost 30 times as great as the steam railroads' passenger carrying capacity. The electric railways have in service approximately 100,000 passenger cars which have an estimated passenger capacity of approximately 4,000,000 passengers. When this passenger capacity is added to that of the steam railroads it is still evident that the automobiles of the country have by far the greatest passenger carrying capacity of any of the transportation agencies.

Freight Carrying Capacity of Trucks

When a study of the freight service is made a different result is seen. The The 2,453,341 motor trucks in use have an average carrying capacity of 1¼ tons. Approximately 82 per cent of the trucks are estimated to be of one ton and less capacity, which indicates that the small capacity truck predominates. The total freight carrying capacity of these trucks, therefore, amounts to 3,066,676 tons. The freight cars, of all kinds, operated by and over the steam railroads of the country number 2,547,169. The total capacity of these railroad freight cars which are in service is reported to be 111,450,034 tons. It appears, therefore, that the total motor truck capacity is but 2.8 per cent of the freight carrying capacity of the railroads. How much freight these trucks actually carry can not be ascertained definitely nor can it be readily estimated. If we assume 10,000 miles as the average annual mileage per truck and apply this mileage and the 1¼ ton average capacity to the total trucks in use we arrive at a total capacity mileage of 30,666,676,500 capacity ton miles. This figure is far from the actual ton miles produced. The various traffic surveys made thus far show that only 2/3 of the trucks operating over the highways carry loads and that these loads average about 80 per cent of the capacity of the trucks. When adjustment is made for these facts it is seen that the estimated ton mileage of motor trucks is reduced to about 16,355,526,667 ton miles. The total freight ton mileage of the steam railroads was reported to have been in 1925—414,139,835,000 ton miles. The estimated ton mileage produced by the motor truck is, according to these figures, about 3.8 per cent of the total freight ton mileage of the railroads of the country. To just what extent this ton mileage was produced over our rural highways is difficult

to tell. If we assume that half of the motor truck mileage is produced over city streets and half over rural highways it would appear that a fair estimate of the services rendered by motor trucks over rural highways is about 8,000,000,000 ton miles. This is about 1.9 per cent of the ton mileage produced by the railroads in 1925.

Highways Essentially Passenger Carriers

These estimates indicate clearly that the highways are essentially passenger carriers and the railroads are still the important freight carriers. There is no doubt that a very considerable number of the passengers carried over the highway by automobile are persons who would avail themselves of the railroad service if motor vehicle transportation did not exist. How large this number is can not be definitely ascertained. About a third of the passengers riding in automobiles on the rural highways are on business, the remainder may be classed as non-business users of the highways. A large part of the number who are using the highways for business purposes would no doubt use railroad facilities, either steam or electric to carry on their business activities, if these highway facilities did not exist. It may be said that a small number of those riding on the highways for pleasure or recreational purposes would travel by railroad if automobile transportation were denied them. Those traveling by busses are mostly engaged in business and almost all of these would go by railroad. But these are the smallest number of persons traveling over the highways by automobile. In Louisiana traffic count it was shown that 93 per cent of the highway passengers traveled in privately owned and operated automobiles and 7 per cent used motor busses.

Railroad Passenger Mileage Decreasing

The passenger mileage on the railroads has been decreasing when compared with the maximum attained in 1920. The Class I steam railroads of the country that year produced 46,848,668,000 passenger miles; in 1925 it stood at 35,963,862,000 passenger miles, but that figure is higher than it was any year prior to 1917. The per capita passenger rail mileage has been greatly increased since 1890. The average passenger mileage per capita in 1890-99 decade was 192 miles; in the 1900-09 decade was 226 miles; in the period 1910-16 it was 345 miles; from 1917 to 1920 it averaged 423 miles (this was during the war and in the years immediately thereafter). During the six year period beginning with 1920 and ending with 1925 the total passenger mileage per capita was 348 miles. This is practically the same amount of passenger transportation per capita as existed in the 1910-16 period when the per capita mileage was 345 miles.

In the absolute number of passengers carried there has been a great decrease. In 1925 the railroads carried 886,650,000 passengers as against 1,269,912,000 passengers in 1920 which was the largest number the railroads ever carried in one year. The number of passenger carried in 1925 was less than that found in any year since 1908 when it was 890,009,000. In this period, however, the average journey per passenger increased from 32.86 miles in 1908 to 40.56 miles in 1925. In 1920 when the largest number of passengers were carried the average journey per passenger was 37.30 miles. During this whole period there has been an almost steady increase in the average length of the journey of each passenger by railroad. From 1908 to 1925 it increased approximately 8 per cent. There is no doubt that the automobile has been the cause of the reduction in the number of passengers carried by the railroads. This reduction has in the light of those figures taken place largely in the local passenger traffic. These figures cannot be made to tell the whole story in a statistical fashion because it must also be observed that in this period the commutation business of the railroads increased vastly, at least in the densely populated sections of the country. This commutation business is all short distance traffic.

The passenger traffic by motor vehicle can be grouped into three classes; (1) the passengers who used to travel by horse drawn vehicles, which are the smallest in number; (2) the passengers who are taken away from the steam and electric lines which form a substantial number; and (3) those who are traveling over the highways by automobile who otherwise would have stayed at home. This last class appears to be by far the largest number. This latter statement, I believe, is borne out by the fact that the railroad passenger mileage per capita averaged 348 miles during the past six years, and that the average automobile passenger mileage on the rural highways is estimated to have been about 950 miles per capita. It stands to

reason that a large part of this may be considered, in the language of the traffic man, as "new business."

Railway Freight Traffic Increases

The per capita passenger mileage produced by the steam railroads remains practically stationary but in case of freight traffic a great increase is observed. The freight ton miles in the decade 1890-99 were 1,355 per capita; in the decade 1900-09 they were 2,247 miles; in the period 1910-16 they were 2,983 miles per capita, and in the period 1917-20 they were 3,830 miles per capita. In the six year period 1920-25 the average freight ton miles were 3,468. The passenger mileage per capita had increased from 276 miles in the 1900-09 decade to 348 miles in the period 1920-25, or 25 per cent. The per capita freight ton mileage increased from 2,247 ton miles in the 1900-09 decade to 3,468 ton miles in the period 1920-25, or 53 per cent. This indicates a much greater increase in the freight ton mileage than in the passenger mileage per capita. But going to the 1890-99 decade we find that the passenger mileage per capita increased 44 per cent in the 1900-09 decade over the previous decade and the freight ton mileage per capita increased 66 per cent. The tendency for the freight ton mileage to increase faster than the passenger mileage was noted even at that time before motor vehicle competition became a part of the picture.

Long distance motor truck traffic is not encountered to a great extent on our rural highways. The average trip mileage in all of the sections of the country where traffic surveys have been made is relatively short so far as the motor truck is concerned. The average motor truck haul ranges from 23 to 26 miles; 40 per cent of the truck movements on rural roads are less than 10 miles in length; 76 to 81 per cent of the trucks are operated over routes less than 30 miles in length. Not more than 2 to 4 per cent of the trucks operating over rural highways travel over 100 miles.

There was a time when the motor truck enthusiast had visions of the motor trucks actually superseding the railroads as carriers of freight. It was believed that that time was close at hand. According to the economic order of things this may be put down as very nearly impossible and impracticable. To carry the goods hauled by a freight train of 50 cars, 50 tons average capacity, it would take a fleet of 500 5-ton motor trucks. A freight car of 50 tons capacity costs about $2,000; motor trucks carrying 50 tons would cost approximtely $50,000. A crew of about 6 men will conduct the operation of a 50-car freight train whereas it would take 500 drivers to drive the trucks required to haul the equivalent amount of freight hauled by the freight train. Although there are 5 employees engaged in railway supervisory and maintenance work for every one engaged in actual train operation service, even with 30 men's wages charged against operating a train, the labor cost is still way below that which would have to be paid to move the same quantity of freight by motor truck. Other comparisons as to mileage, etc., could also be made, but enough has been shown as to why the motor truck can not be considered a serious competitor of the railroads in the moving of freight over long distances.

Motor Trucks Distinct Field of Service

The motor truck's distinctive field of service is in short haul area where pick-up and delivery service is essential. The commodities hauled are primarily foodstuffs and perishables; about 40 per cent of the traffic consists of vegetables, fruits, milk, agricultural produce, and truck crops. This is really an element of market distribution. On the railroads the products of agriculture and of animals comprise about 11 per cent of the total tonnage. Another significant movement by truck is the hauling of building materials, gravel, crushed stone, rock, and lumber. These are all short distance movements usually from a yard or quarry to the point where they are being used.

Where so-called long distance hauling by truck takes place it is usually found that it consists of specialty hauling, such as furniture, or it consists of commodities where time is more essentially a transportation element than costs.

The annual costs of conducting our highway transportation are naturally of great interest. The reports and cost statements filed by operating companies show what those transportation charges amount to for a year's period on the railroads. Similar records are wanting so far as highway transportation is concerned. With almost as many individual owners and operators as there are motor vehicles it is impossible to arrive at an actual and accurate cost figure. Furthermore, the highway expenses are costs which are in the first place met out of

public funds. The public treasury in turn is reimbursed through special fees and charges levied upon the users of the highways and through general property and other taxes.

Motor Vehicle Operating Costs

A statement has recently been made that the operation of motor vehicles costs the American public $14,293,000,000 a year. The estimated expenditures and costs in that statement are grouped under eleven items. Such annual costs would amount to $700 per motor vehicle, and if an annual mileage of 5,000 miles per vehicle is assumed it would result in an average cost of 14 ct. per motor vehicle mile. The operating cost data which have been secured from various sources indicate that 14 ct. per mile is excessive, as an average cost per mile, including interest depreciation, maintenance, etc. It is generally believed that an average of 10 ct. per mile is a figure which can be more readily substantiated by cost figures. One of the fundamental criticisms which can be made of this $14,000,000,000 estimate is that there is included an estimated figure for annual interest charges and also the sales price of all motor vehicles and accessories sold during the past year. This results in a duplication and does not reflect a true conception of annual operating costs. An estimate of about $10,000,000,000, a year it may be asserted, covers the operating costs of the country's 20,000,000 motor vehicles. This is based on the average figures of 10 ct. per mile and 5,000 miles per year. The country's annual highway expenditures amount to about a billion dollars per year. Motor vehicle transportation involves an annual cost of about $11,000,000,000.

In this connection it should be observed that the highway costs are only about 9 per cent of our total motor vehicle transportation bill. I appreciate that no estimates are included covering city street costs because they are too difficult to make. If through the improvement of our rural highways the per mile costs of operating the motor vehicle can be reduced it can be regarded as an economical expenditure. The revenues of the steam and electric railways of the United States in 1925 were approximately $6,750,000,000. It would appear therefore that the transportation costs by motor vehicle are about twice as great as the money expended yearly for steam and electric railway transportation.

Revenues from Motor Vehicles

The motor vehicles in a direct manner contribute very substantially to the revenues necessary to meet the total annual highway expenditures. In 1925 the total license fees collected amounted to $260,619,621 or $13.06 per vehicle; the gasoline tax yielded $146,028,940 or an average of $7.28 per vehicle. The license fees and gasoline taxes for the country as a whole averaged $20.28. All of the revenues collected in this manner were used for highway purposes with the exception that 1.3 per cent of the license fees were used up for administrative purposes, and 4.5 per cent were diverted to uses other than highway. Only a fraction of one per cent of the gasoline tax was retained to meet collection costs and 7.5 per cent of it was used for other purposes. It should be noted in this connection, however, that the collective and administrative costs are not charged in every State against the motor vehicle funds but are met through other appropriations. So these administrative and collections costs as given here to do not include such costs in all of the States.

There is a great variation in the license fees charged by the several States; the average per vehicle ranges from $2.82 in the District of Columbia to $24.79 in Oregon. It should be said, however, that in Oregon and in certain other States where the license fees are high the motor vehicle is exempted from all other taxes, State and local. There still 11 States and the District of Columbia in which the average license fee is less than $10 per vehicle. The gasoline tax as a means of raising funds for highway purposes is used in all of the States except Illinois, Massachusetts, New Jersey, and New York. There are now two States which have in effect a tax of 5 ct. per gallon; 1 State 4½ ct.; 4 States 4 ct.; 3 States 3½ ct.; 10 States 3 ct.; 1 State 2½ ct.; 21 States 2 ct.; 3 States 1 ct.

Not enough time is available to discuss adequately the subject of highway finances and the methods and policies which are followed to produce annually the large sums of money necessary to construct and maintain the highways of the country. Let it be sufficient for the time being to point out that in addition to the above mentioned license fees and gasoline taxes amounting to over 400 million dollars, the motor vehicle owners last year paid over 140 million dollars into the Federal treasury as excise taxes

upon the purchase of new vehicles, tires and accessories and that the property taxes paid upon motor vehicles have been estimated to amount to approximately $150,000,000 a year. In addition to these direct payments by motorists there are so-called wheelage taxes and special local license fees, collected in many States, which have been estimated as amounting to about $50,000,000 a year. All told the motorists through license fees and taxes may be said to pay out annually to the government about 740 million dollars which is about three-quarters of the total highway bill. It can be well believed that the taxes and the contributions which industries and business men dependent upon the motor industry and highway transportation make are enough to offset the balance of our annual highway bill. Accordingly the burden of financing our highways rests largely upon its users.

Saturation Point for Motor Vehicle Ownership

To estimate the saturation-point of motor vehicle ownership has been a favorite in-door occupation for many who have taken an interest in the subject. The question constantly arises as to how many motor vehicles the country is going to have and what is the limit. This was discussed by Leonard P. Ayers, vice president of the Cleveland Trust Co. and one of the ablest of the country's economic statisticians, in a treatise called "The Automobile Industry and Its Future," published in 1921. "It seems clear," he said, "that nearly every family would like to own a passenger automobile, that many individuals would like to own cars in addition to the family machines, and that there are few commercial and industrial establishments that would not possess commercial cars or trucks if they could." The fundamental situation is that the ability to purchase and maintain a car is in most cases the limiting factor. In 1920 there were 9,231,941 motor vehicles registered; these were the latest figures Mr. Ayers had available. After studying carefully the length of life of a car, the average income of individuals and families, and the productive capacity of factories, Mr. Ayers concluded that "the use in the near future of anything like twice the present number of motor vehicles seems most unlikely." At the end of 1925, within five years, the "unlikely" had come to pass; the country had in use 20,051,276 motor vehicles. The absorbing power of the public had been underestimated. The saturation-point is just as difficult to compute now as it was then. The extended use of the motor vehicle depends largely on the continued prosperity of the country and on the traffic in and about our large centers of population.

Regulation of Common Carrier Motor Vehicles

One of the problems involved in this subject of highway transportation which is freely discussed at the present time pertains to the regulation by the public of common carrier motor vehicles. At the end of 1925 there were 27 States which regulated common carrier motor bus and motor truck operators; 7 States regulated motor buses but not motor trucks; 2 States had in effect a limited regulation of buses; and there were 12 States which did not regulate common carriers of either persons or goods. In all of the States where an attempt is made to regulate common carrier motor vehicles, the legislature defines what is meant by a common carrier. In most cases the regulation is restricted to those motor vehicles which carry persons or property for hire over definite routes between fixed termini and on regular schedules. Many of the States have taken great pains to work out a set of principles and practices relating to the regulation of this type of common carrier traffic which is increasing in its importance every day. A great many practical difficulties are encountered in the efforts to regulate as a public service facility the motor vehicle freight carrier.

NEW PRESIDENT OF A. A. E.

C. J. Ullrich, member of the firm of McGonagle & Ullrich, consulting engineers, Salt Lake City, Utah, has been elected president of the American Association of Engineers for the ensuing year.

Mr. Ullrich began his engineering work with the Leonard Construction Company of Chicago immediately after graduating from college. He served as resident engineer on the construction of the Idaho Falls Municipal Hydro-Electric Plant & Pumping Station on the Snake River and as office engineer for the Utah State Road Commission. In 1913 he was appointed Deputy State Engineer of Utah, which position he held until 1921. Since that time he has been a member of the firm of McGonagle & Ullrich.

Mr. Ullrich is also an attorney-at-law, and confines his legal practice to engineering matters entirely.

"The World of History," says Mr. Ullrich, "is only about 6,000 years old, yet that 6,000 years represents by far more human progress than all the other ages through which man has ever lived. Who will dare say that the Great Pyramids, the Hanging Gardens of Babylon, the tunnels under the Euphrates, the Temple of King Solomon, or the Cathedrals of Europe were not constructed by the engineers of that day? So even our complex life of today is founded almost entirely on engineering achievements. The train we ride on, the ship we sail on, the telephone we talk over, the typewriter we write on, the building we office in, and a thousand and one other things that enter into our lives are the achievements of the engineers of today.

"Tregold has said, 'Engineering is the science and art economically applied to the laws, forces, and materials of nature for the use, convenience, or enjoyment of man.' The engineer is dealing with materials and forces, with objects of an inanimate nature and with the laws and forces acting thereon. His training and experience are apt to make him cold and austere in his ideas and beliefs and untouched by the human passions and feelings of the ordinary man. His training and experience also makes him individualistic in nature and when called upon to use men and enthusiasm to build up support for ideas and ideals, everything seems indefinite and as a rule he is lost. As a result the engineer of the past has shrouded his work in an air of mystery. He has held his problems aloft from society. In the words of Tregold, if the engineer of today wishes to become successful he cannot like the engineer of yesterday retire into the technical recesses of his profession and content himself in being the servant of other men. He must be broadminded, aggressive, alert, and in touch with the problems of the public and society, and above all he must be a leader. It takes far more than a technical training to make a professional engineer. It has been said that the three essential requisites for an efficient and successful engineer are: A good strong character, sound professional knowledge, and a knowledge of business and human relations. What makes a good strong character? That, I believe, is acquired through the proper association and environment. Association with men who are higher up in the profession than you are; with men who have established a code of ethics. Sound professional knowledge may be acquired through training and practical experience, training through schooling; experience, through actual accomplishments. Practical experience may be divided into two classes; that obtained through personal achievements and that obtained through association and a knowledge of how the other fellow has succeeded. It is just as important to know of the other man's failures as of his success for a man's failures often teach us more valuable lessons than his successes. So here again comes association with men who have had a broader experience, with men who have been successful and who are willing to give you the benefit of their experiences. This constitutes an important part. A knowledge of business and human relations can be obtained only by taking an active interest in public affairs and in the problems of life and society, of a human nature. Membership in engineering and civic organizations such as the American Association of Engineers and the technical societies gives you an opportunity to develop this class of knowledge.

"A man's technical experience or college training, is merely the foundation upon which he can expand into the broader phases of the profession. It is but a stepping stone. By taking an active interest in the problems of his fellowmen, his city and his country, the engineer can improve his social status.

"The engineer should hold it his duty to take part in the political problems of his community.

"Ours is the greatest and most liberal form of government in the world and it is our duty first of all as citizens and second as engineers to see to it that our government is maintained and nurtured by a politics that is clean, wholesome, and progressive. This can only be done by the citizenry of the country taking an active interest in politics, and by this I mean the better class of citizenry, the thinking men of the day.

"The American Association of Engineers is one of the most forward steps that has been taken in the engineering profession for the last 20 years. It is less than 12 years old and is today a moving virile force that is gathering impetus with each year. Its organization is non-technical, in purpose and it con-

fines its activities entirely to welfare work along social and economic lines. It's policy platform is one of service. Service to the public and to the engineer. Through service it is endeavoring to get the engineer to take an interest in his state, and in his community. Through service it is trying to improve the social status of the engineer. Through service it is trying to better the condition of the engineer and the profession. In short, it is a clearing house for the engineer to express himself on all questions of the day."

ENGINEERING THE CREATIVE PROFESSION

Dr. D. B. Steinman, of New York City, in his presidential address before members of the American Association of Engineers, in convention in Philadelphia, Pa., on June 14th, declared that Engineering is the Creative Profession. "On no other class of men are we so dependent for our luxuries, our comforts, and even our necessities as we are upon the engineer and his work," said the speaker.

"The engineer is one of the most highly trained, practical, efficient, hard-working, creative and indispensable servants of society. The engineer, of all professional men, is the greatest contributor to the economic progress and wealth of the community.

National Prosperity Is Dependent on the Work of the Engineer

"In this era of international economic competition, the wages of labor are ultimately determined by the efficiency of production, and national prosperity may be measured by the purchasing power of the workers' earnings. If American industries can compete in foreign markets while maintaining higher wages and shorter hours for our workers, that is only because of the greater efficiency of production in this country. This increased output of the individual worker represents the engineer's contribution to industry. Through the development and extension of labor-saving machinery, the scientific planning of plants and processes, the introduction of the prinicples of efficiency in management, organization and operation, the engineer has speeded up production, eliminated waste, and increased the output of the individual. The engineer has thereby made possible the higher earnings, the shorter hours, and the higher purchasing power of the workers' wages—all things that constitute the foundation of our national prosperity. The community or nation that best develops and applies the brain power and inventive genius of the engineer will be the most prosperous.

Civilization Is Dependent on the Work of the Engineer

"Public attention is often directed to the depletion and approaching exhaustion of some of the natural resources which we have come to regard as indispensable. We are told that the end of of our coal supply is in sight, that our petroleum supply will soon be consumed, that our timber supply is rapidly vanishing. It is the work of the engineer to prolong the availability of such fundamentally important natural resources through improvements in their economic utilization, through the scientific elimination of waste in production and in application, and through the opening and development of new sources of supply. It is the problem of the engineer to anticipate the depletion of these natural resources by devising and developing new methods, processes and constructions that will dispense with the need for the materials and supplies that become scarce or prohibitive in cost. The engineer's development of hydro-electric power has reduced our dependence upon coal for power generation. The engineer's opening of petroleum supplies and his development of the internal combustion engine have further liberated us from our dependence upon coal. The engineer's development of steel and reinforced concrete, successively, as structural materials has relieved our dependence upon timber for construction. To meet the problems of a diminishing supply, the engineer is now developing railroad track ties of steel and concrete where timber has hitherto been considered indispensable. The engineer is developing and applying alloy steels and new steels of vastly increased strength to reduce the amount of metal required in his structure. Long before the iron supply reaches the vanishing point, the engineer will find effective substitutes; or he will have brought aerial transportation to such development as to dispense with the need of steel for rails and bridges. Civilization and human progress depend upon the resourcefulness and ingenuity of the engineer to solve each successive problem of vanishing natural resources.

"In almost every step of our daily

lives, we benefit by the work of the engineer.

"Through the work of the engineer, the luxuries of past generations have become the necessities of today.

"The engineer has done more to promote comfort, wealth and safety than the members of all other professions combined have done since the world began.

"All these things must be brought home to the general public, to the end that there may be better appreciation of the engineer and his work.

"Such constructive publicity constitutes an important part of our Association's program of service to the profession.

"Our Association is undertaking the preparation and publication of a book that will help to educate the public on the high value of the engineer's services and contributions to modern civilization. Other material of interesting information or advisory nature will be included, designed to give the public a better appreciative understanding of the engineering profession. The preparation and distribution of books and pamphlets containing such constructive educational material will be a real service to the public and to the profession.

"We must call upon the press to help us in our program of public education.

"We must supplement such publicity activities with the organization of a speaker's bureau, with men trained to address the public on the high contributions of the engineer, and on the outstanding problems of our profession.

Protection of Our Professional Title

"An important activity of our Association is the protection of our professional title.

"The proper recognition of the engineer as a professional man, and of engineering as a learned profession, is retarded so long as the title of 'engineer' is shared by non-professional men.

"The designation 'physician' and 'lawyer' are distinctive for their respective professions. But the title 'engineer' is commonly applied to men who operate steam engines or drive locomotives; and the resulting confusion and misunderstanding are further aggravated by the widespread and growing misappropriation of the designation 'engineer,' in multiplied hyphenated forms, by men who have no claim to an engineering title.

"We find plumbers placing 'Sanitary Engineer' on their signs. Electricians and bellhangers style themselves 'Electrical Engineers.' We also read announcements of 'domestic engineers,' 'clothing engineers,' 'exterminating engineer,' 'matrimonial engineers,' and a hundred or more other kinds of engineers, none of whom need to know anything about engineering science and its application. A consequence of this unhindered and indiscriminate use of the title 'engineer' is a weakening of its prestige and distinctive significance. The members of the engineering profession find that the use of their title, 'engineer,' does not invest them with the dignity and standing that are naturally possessed by the holders of other professional titles.

"Through educational publicity we must conduct a persistent campaign to discourage the abuse of our professional title.

"Through registration laws we must seek to restrict the use of the designation 'engineer.'

"We must stimulate and encourage revisions in nomenclature to distinguish between 'engineers' and 'enginemen.' The mechanic who drives or repairs a steam engine, however skilled he may be, should not be styled an 'engineer' to the detriment of the public standing of engineering as a professsion. The man at the throttle of a locomotive, however picturesque a figure he may be to the layman, should be distinguished from the professional man who designed the locomotive and the transportation system of which it forms a unit.

"The American Association of Engineers is the only national organization devoted to the human side of the engineering profession. Its purpose is to bring engineers together in a professional brotherhood in mutual understanding, helpfulness and co-operation. The advancement of this purpose alone is ample justification for the continued existence and growth of the Association.

"Thousands of engineers throughout the United States are banded together in this organization. We are uniting our efforts to make pleasanter the relations and working conditions within the profession. We are seeking to relieve the engineer of economic pressure so that his best energies may be free for his high service to civilization and human progress. We are striving, through organized effort and publicity, to secure for the engineering profession its rightful

place in public esteem, and for the members of that profession more adequate recognition and recompense for their services to society."

SURVEY OF CONSTRUCTION CONDITIONS

In its national survey of construction conditions recently made the American Construction Council notes the following findings:

Although the first four months of 1926 showed the greatest volume of building construction yet seen for the same period of any year and exceeds by 20% the similar period for 1925, which itself was a record breaking building year, this condition is not uniform as some localities show a recession and there are some indications toward greater moderation. The last part of April showed a slight seasonal decrease from the rate of the preceding months, which, however, is partially due to the fact that spring work has come into the market earlier than usual this year as a result of the continuous campaign for all year round work carried on by the Council and its affiliated branches of the industry as well as by the government.

It is difficult to tell whether the growth of new industrial and commercial buildings will continue to go down on the books the next six months as fast as it has during the past year. A distinct note of caution has been sounded by many groups. In the matter of high priced apartments and hotels a similar note of caution has been sounded. It is only in the group of medium priced well built private dwellings that the demand seems to warrant real optimism. This demand for homes must not be confused with artificial real estate booms.

What is needed as to volume of construction is of course steady all-year-round and year-in-and-year-out work on a sound level, and whatever can be done to maintain this is much more important than mere peak production. In addition to what is being done by the industry itself, the efforts of the Federal government as well as of various states toward this end in the scheduling of public building programs is highly commendable.

The outstanding need still remains that of suitable housing for persons of average means at a fair price. What the Council pointed out last Fall still holds true—that the large volume of building construction has not yet met the country's real housing need. City residential construction continues in the main to be of the larger and higher priced apartments and hotels, and the more active suburban home developments are still too frequently high in price or inferior in quality.

The construction of large building is reflecting more and more, however, the increased demand of the public for better built buildings as urged by the Council for the past several years, and a similar demand is beginning to show itself on the part of the prospective home owner of moderate means as evidenced by the nation-wide demand for the Council's recent pamphlet "Six Steps in Building or Buying a Home" which has received the hearty approval of the responsible elements of the various branches of the construction industry as well as of the public. But further awakening of the public consciousness to the value of better building and an ever present insistence on the part of the home buyer that he get real value for his money are still needed.

The Council urges the prospective home owner to deal only with reliable persons in all the stages of buying or building a home—location, financing, design and building. He should also insist upon first class materials and first class workmanship both in the structure proper and in its equipment.

Likewise, the investing public whose money goes into mortgage bonds and other present day forms of financing large building construction should insist upon first class construction in both materials and workmanship on all buildings into which it puts its money and deal only with reliable loaning institutions from whom it can obtain full facts as to not only the nature of the security but the character of the building and supervision of the structure itself. In doing this the public must consider every building as a separate and distinct problem, for the safety of building loans cannot be characterized as a whole as either safe or unsafe.

As the Council noted in its statement last fall, the passing of the acute building shortage and temporary building booms in some localities with the consequent return to normal consideration of building values will make structures of inferior quality an increasingly heavy liability.

It is such insistence on the part of the public that the essentials of right construction be put into actual practice—from financing of the project and the design and erection of the building to the supervision of the finished structures—that will maintain the building industry on a healthy basis. To make this insistence effective the public must cooperate with persons of skill, vision and responsibility in all branches of the industry.

Regional planning of large and small cities as to both beauty and utility as well as the proper development of smaller centers and suburban districts should have the hearty support of the public. Even the smaller towns and villages which anticipate future growth should conduct intelligent town planning. The flow of traffic to and from the large centers and its relation to building development is also becoming an increasingly serious problem and should receive consideration in this connection.

The market for building materials continues in general to be satisfactory, although in some branches of the industry a disposition to buy only for immediate requirement is seen.

Labor productivity continues to be relatively favorable which helps to reduce actual costs, although wages have advanced in some instances. Any increases in wages will, it is hoped, carry a corresponding increase in skill and proper productivity.

Money for building purposes continues to be readily available in most locations but the element of caution is playing a greater and greater part in regard to speculative building operations.

The outlook for highway construction indicates the largest yearly volume in that branch of the industry yet seen. The Council therefore urges the public to insist that its representatives who have charge of such construction be instructed and given the necessary authority to conduct their program so as to make for more and better highways of first class construction. Otherwise the utility of the highways will soon decline and the taxpayers of the country will in a few years be called upon to duplicate this large expenditure of public money which if wisely spent is a great national asset but if poorly spent becomes only an increasing economic burden.

INCREASING SAFETY OF STATE HIGHWAYS

By R. M. Morton, State Highway Engineer, Sacramento, Calif.

(Editor's Note: The following is from a paper read by Mr. Morton before the 1926 meeting of the California Supervisors' Association.)

Inasmuch as one in three persons in California is responsible for the operation of a motor car, the subject of safety on the public highways is of constant public interest. There are perhaps three classes of danger which threaten the motorist.

First: Weaknesses in his vehicle itself. Records show that a prolific source of accident are those from worn tires, the breaking of wheels, the crystallizing of steering arms or axles. From this class of trouble the road builder can not be held responsible.

A second class of accidents is caused by the imcompetent or irresponsible driver, who is an ever present menace to himself and to all others. Until some system is inaugurated for mental tests for operators, which will weed out the physically and mentally unfit, automobile driving will contain a large element of danger.

The third class of accidents includes those for which road conditions must share in the responsibility. This cause is inseparably related to the second, for the safe and careful driver tries to adjust his control of the machine to the highway conditions which he perceives immediately before him. However, in California, with the large mileage of smooth straight roads and the generous legal speed limit, the motorist has gradually come to believe in his right to proceed at the maximum of the legal rate of speed over the highway surface, in any location outside of cities and built-up sections. The universal use of the automobile for the transaction of every kind of business and pleasure has created public demand for safety in the highways. The efforts of the road building agencies, both county and state, to provide smooth, hard surfaces, capable of sustaining high speeds, is generally taken by the motorist as a recognition of his rights to proceed at the maximum speed which the law allows. The motorist has gradually become more exacting in his demands regarding all details of highway improvement.

Experience Shows Danger

Improved highway construction in

California has had crowded into its fifteen years of intensive history, a vast wealth of experience, example and precedent as to safety details. The state and county highway builders are better able now than ever before to state in exact terms what details constitute danger in highways.

There are many details in the design of highways which have little influence on their efficiency for slow moving traffic, but which threaten the safety of the fast moving vehicle. At low speeds almost any improved highway is safe, assuming a good car and an experienced driver who has the ordinary co-relation of his senses. However, now it is for the faster traffic that we must design our highways, if we desire to reduce danger to a minimum.

The ideal highway should have sufficient width to accommodate the pavement, plus a margin of usable width to permit a car to get completely off the pavement at all points. The Motor Vehicle Act makes it a misdemeanor for a car to stop for repairs on the paved portion of the roadway, and the time is at hand when this provision should be more strictly enforced. There is no more serious menace to traffic than a car stopped on the pavement. It is an invitation to death for the person in the car which is stopped. Many an accident has been caused by the meeting of two other vehicles at a point opposite the disabled car. At night it is doubly a menace, for it is often impossible to know quickly when approaching a red tail light, whether the car is stopped or is moving.

If a shoulder wide enough to permit of parking clear of the pavement is not provided by the road builder, the motorist is forced to stop upon the pavement.

Borrow Pits Menace

We now know that the high grade with deep borrow pits scooped out in the right of way is often a death trap for the motorist. So many accidents occur on account of these deep borrow pits that it is almost axiomatic in the state highway department that they are not to be constructed. Although drainage provisions are usually necessary, in country which seems to require construction by means of deep borrows on the sides, the excavation often greatly exceeds drainage necessities. When a grade is built by robbing the roadside, the drainage conditions are usually made worse instead of better, because ponds of water stand in the borrow pits, to the detriment of the roadbed.

No road should be paved to a less width than 18 ft. Traffic on all of our public highways is now reaching a point where two lines must be provided. However, the 18 ft. width of roadway does not provide any factor of safety to permit the free, easy, and safe passage of an automobile and a wide truck or stage. The pavement is built to take the traffic, and the road builder can not assume that the driver of one vehicle should get half way off the pavement to pass a wide load. Widths of 20 ft. are considered to be necessary if we are to look a little to the future, and assume the greater use of highways which is bound to come.

The junction between the firm material of a hard pavement, and the earth of the grade, is a great danger point on all paved roads, and a fruitful source of accident to the motorist. In rainy weather, if he leaves the pavement with one wheel to pass a vehicle, he sinks into the soft slippery shoulder, then endeavors to climb back by a quick turn on the steering wheel. Sometimes he goes across the pavement into the other traffic lane, thereby endangering the lives and property of those using that side of the road. Many accidents occur on low soft shoulders by the car overturning before its wheels climb back to the pavement.

This is a situation which road builders should not tolerate and can do much to prevent. It is the endeavor of the state to protect the edge of all new pavements by an additional two feet of crushed rock. The purpose of this is to widen the usable hard surface, as well as to create a transition area, the outside edge of which will not be so rigid or so abrupt as the edge of the hard pavement.

A good means of keeping traffic off the shoulders of the highway is to supplement with rock the width of the pavement and to permit vegetation to grow on the sides. It is noticed that motorists are much more careful to keep off the grass than off a smooth appearing earth shoulder. This reduces maintenance expense and at the same time it increases safety by encouraging more careful driving.

Safe Curves Appreciated

Curvature in road alignment has ceased to be a pet of the engineer, used by him only to cause right of way difficulties for the supervisors. The motoring public has become educated to the difference between a 100-ft. radius curve and 300,

500 or a 1000 ft. He knows there are certain bad bends which require reducing his average speed to one half, and that there are others around which he can travel without slackening. He appreciates the safe curve. A highly superelevated curve of 300 ft. radius is about the minimum which the average driver can safely negotiate at a speed of 35 miles per hour. The center of a 300 ft. radius curve at a right angle corner will lie about 125 ft. from the intersection of the two straight lines. A 500 ft. radius curve will lie about 200 ft. in from the intersection of the two straight lines.

When first considered, the idea of taking valuable property just to ease up a corner for the speeding motorist may seem unreasonable, but these and even more drastic lines are necessary to build real safety into the roads. If the highway is to be paved, there will be an actual saving in length of pavement by installing a 500 ft. radius curve instead of building a right angle of over 200 ft. in length. At $4 per lineal foot for the pavement, this amounts to over $800 saving in cost of paving construction, which can be devoted to procuring the new right of way. On a curve of 1000 ft. radius in such a location, the difference in length of pavement would be over 400 ft., which at the same rate would permit of $1,600 being devoted to procuring new right of way.

Superelevation is another semitechnical term loved by the engineer and by the motorist. It means simply the banking, or raising of the roadbed on the outside, to make the car lean to the inside as it passes around the curve. Combined with force of gravity and the centrifugal force, a properly banked curve keeps the center of gravity of the car properly spaced between the wheels in contact with the roadbed. Railroad tracks are laid out with superelevation on the curves, thereby permitting high speed trains to take them without slackening speed.

The necessity of superelevatiion as a safety measure on the public highways, is now a well learned lesson.

Importance of "Sight Distance"

The term "Sight Distance" denotes the distance which the motorist traveling on the right side of the road can see past an obstruction, to sight an approaching car. Human beings differ in their time of recording sensations on the brain and getting the muscles into action. Some drivers are slow in their reflexes. A car moving at 30 miles per hour travels 44 ft. in one second; at 40 miles per hour it travels 50 ft. in one second. Assuming that two cars are approaching each other at 30 miles per hour around a curve, the distance between them is lessened by 44 ft. in one second for each car, or at a combined rate of 88 ft. per second. Therefore, with a sight distance of 88 ft. on the curve, there would be one second for the senses of the drivers to act, for the muscles to act, and for the vehicles to respond and pass safely. Any such small distance is entirely too short to permit of a speed of 30 miles per hour. The average driver will require one second to adjust himself, one second should be allowed for the vehicle to respond, and there ought to be one second to spare. Therefore, a sight distance of 300 ft. is the minimum which can be considered really safe. Even around curves from which obstructions have been removed to make a sight distance of 300 ft., speeds greater than 30 miles per hour are hazardous. Sight distances must be increased to four or even five hundred feet in order to permit of safe travel at a speed of forty miles per hour.

Sight distance also comes into the calculations of the road builder on vertical curves, where two cars will approach the crest of a hill from opposite sides. In such cases curvature should be such that there is as long a sight distance as possible. To pass a vehicle going in the same direction when approaching the crest of a hill is always dangerous, until the driver has a clear view of the road ahead over the top of the hill. Good practice requires that the crest of the hills be lowered by means of long, flat vertical curves.

The problem of railroad grade crossings has consumed the time of many committees during the past few years. The grade crossing catches good and poor drivers alike. There is only one safe rule for the motorist in approaching a grade crossing, that is, to slow down to a speed which permits him to carefully look in each direction when still at a good distance from the crossing, and assure himself personally that a train is not approaching. Warning signs, bells, human flagmen, wigwags, and even traffic gates do not protect the motorist who does not take this common sense precaution. We sometimes say that he kills himself, but that does not repair the loss sustained by society when a car-

load of passengers is wiped out in an instant. The Railroad Commission of this state had adopted a policy of refusing to open grade crossings except when another is closed.

Grade Crossings Part of Improvement

There is one good rule for the highway builder, and that is, never to improve a highway at grade across a main line railroad. If the highway is worth building, it must be because of the amount of traffic, and if the amount of traffic justifies building the highway, it usually justifies going a little farther and planning a grade separation to be constructed along with the highway project.

The practice which has become fairly standard in California is to assess one-half the cost of the project to the railroad, the other half being borne by the public. Although this phase of highway work is expensive, and adds to the number of major structures which must be built, there is nothing which is more appreciated.

The points above enumerated, which make for safety, have to do entirely with the designing and building of the road. They include the width of grade and pavement, the avoidance of death trap borrow pits, treatment of the shoulders, the alignment of the road, superelevation of the surfacing, sight distance on curves, and railroad separations. If a highway is well laid out with due attention to all of these details, the road builder has gone far in safe-guarding the user of the highway. There are additional minor safety measures, the need for which should be studied by the road builder after the highway is in operation. These are improvements or betterments of a minor nature, which contribute added safety for fast traveling motorists.

One very important measure, which is highly conductive to safety, is the center guide line, which divides the pavement into traffic lanes. This is a great help to the motorist, both day and night, for it marks off a certain width for his exclusive use, and he proceeds with the assurance that the approaching motorist, desiring similar courtesy, will not encroach upon his side of the road. Workmanlike guide lines are not easily installed. White paint makes the best guide line on either cement or asphalt surface, at a cost of from $40 to $50 per mile. Black guide lines of asphalt paint can be installed for $10 per mile or less, where there is much of it to do.

A white guard rail of substantial character looming up at night is a true friend of the motorist. He should have the same feeling for it that the mariner has for the lighthouse on an unfamiliar sea. Guard rail, to be really worth while should be sufficiently substantial that it will successfully resist an occasional sideswipe. The state of Pennsylvania standardizes on the use of heavy cables on extra heavy wooden posts. This guard is considered practically unbreakable, and I am informed that even trucks do not go through the heavy type. Even a light guard rail, however, is entirely serviceable as an indicator of danger. The motorist highly appreciates this installation made for his particular benefit. The guard rail now standardized on California state highways consists of 8x8 posts, 6 ft. apart, and 6x6 rail, and costs from 80 cents to $1 per lineal foot.

Flasher signals, many of which have been installed by the automobile clubs and associations, in some cases with financial aid from the counties, are a valuable safety device. The presence of a danger spot or a sharp turn in the road is indicated by these flashers, and many lives have been saved by the advance information thus given to the driver of a car.

Safety Should be Built into Highways

The question as to how a county can afford to spend on the installation of safety devices can be answered from two different angles. The first answer is that safety should be built into the highways. A road alignment which is safe usually costs little more than one which is unsafe. The right of way expense, often magnified to be a serious item, in many cases is overbalanced by the savings to be made in reduction of distance. The wound caused by obtaining proper right of way is rarely deep and soon heals.

The adoption of adequate pavement width is an economy so far as future maintenance is concerned because of the distribution of traffic over a greater road surface, which prevents the concentration which tends to break up a pavement.

Grades should be intelligently laid. Materials should be hauled in for making fills instead of scooping out borrow pits. Obstructions to sight should not be permitted. Grade curves over summits should be long and flat. Buildings, poles or other encroachments, including trees

in the line of sight, which endanger the life of the motorist, should be kept clear of the roadway.

The other answer is in the close study of each mile of constructed road, its traffic and its accidents. Many of these can be prevented by relatively inexpensive installations of guard rails, flash warning or reflector signs, and traffic guide markers.

The counties of this state, excluding Los Angeles and San Francisco, in 1925 received an average of about $100,000 each from the gas tax and motor vehicle license fees. Los Angeles County paid 40 per cent of the approximate $20,000,000 total of receipts from license and gas tax, and received back for its own expenditure 20 per cent, or $4,000,000. San Francisco County paid 8 per cent of the total amount collected and received back 4 per cent, or about $800,000. The average return to the balance of the counties of the state was almost $100,000. This fund contributed by the motorist could well be expended in each county in making the highways safter for motor travel.

PUTTING BUSINESS IN GOVERNMENT AT BALTIMORE

By W. J. Casey, Vice-Chairman Commission on Efficiency and Economy, Baltimore, Md.

Editor's Note: The following article appeared in a recent issue of the Baltimore Municipal Journal.)

The question is often asked why our big American sities with the business genius of their own people do not have management as effective and as resultful as that of the great industrial, commercial and public service corporations of this country.

The city of Baltimore presents an answer to this question by inviting attention to what has been accomplished in this regard by the present city administration. Mayor Jackson on the day of his inauguration into office in May, 1923, announced a program for applying modern business methods to the management of the city of Baltimore. City business to him was big business and he turned for advice and assistance to big business as represented by a number of large private business corporations. It was noted that these corporations had trained men to follow their expense dollars, in some instances maintaining research departments to pursue lower costs and higher efficiency. It was further noted that the only expense dollar private business did not follow was its tax dollar. Mayor Jackson adopted the suggestion that he enlist in the problem of applying business methods to city management the men employed by private business corporations to follow their own expense dollars.

The Commission on Efficiency and Economy

The mayor put this idea into action by creating the Commission on Efficiency and Economy, composed chiefly of officers of large private business corporations listed among the heaviest taxpayers of the city. He promised to open wide all city departments to the commission, to sponsor and put into effect its recommendations. Mayor Jackson has lived up to this promise.

The commission organized a staff of about 150 accountants, engineers and organization specialists, loaned by private business corporations or volunteers from private practice. The city of Baltimore paid the salary of the executive secretary and stenographer of the commission and some minor incidental expenses. There is no compensation from the city to the commission or its large staff. A number of city employees assisted in the work. Most of the work of the commission has been accomplished and new methods introduced are already producing results. Foremost in the results of the application of business principles to the municipal management of Baltimore is the wiping out of a deficit in city operations in 1923 of $1,130,000 and the progressive reduction of the local tax rate on each $100 of assessment of the real estate and personal property from $2.97 in 1923 to $2.90 in 1924; $2.58 in 1925 and $2.48 in 1926 with prospect of a still lower rate in 1927.

Commission Had to Create Its Own Procedure

The commission found no similar undertaking by any other American city and had to create its own procedure. This was started by making a number of surveys of city operations. It was found that Baltimore as one of the older cities had followed the general fashion of creating new departments to meet the requirements of city growth and there had been built up some 45 city departments with the usual duplication of similar functions.

An accounting survey made by 25 ac-

countants assembled data as to the accounting work scattered through the various departments. This made manifest the opportunity for consolidation of similar classes of work.

For example there was found over 50 separate payroll and paymaster operations with 130 employees working part or whole time and using methods that did not provide an audit of payrolls before the money was paid out. Some $12,000,000 were then being paid out annually under this system. Payroll experts borrowed from private business corporations designed and installed a central payroll system under which payrolls are audited before the money is disbursed and all the work performed by 23 full time employees.

Collection of Revenue Centralized

Revenue collections—taxes, licenses, water rents, fees, etc., were scattered through 21 departments and the lack of control accounts made it impossible to exhibit uncollected revenue so that it could be followed in the same way that private business handles collections. This survey disclosed over $11,000,000 of uncollected revenue. An intensive collection drive has already collected most of these arrearages. Heads of revenue collection departments of large corporations loaned the city devised and installed a central collection system planned to take care of all collections with 66 employees and five supervisors, compared with 108 employees under the old system. This Central Bureau of Receipts employs the controls and methods of private business to safeguard operations from errors and irregularities and exhibits periodically all uncollected revenue so that the city executive can keep close watch on this vital factor. Many conveniences to taxpayers are embodied in this system.

A Bureau of Disbursements was installed to centralize control of expenditures made and to be made. Commitments to spend money not provided are prevented by this system. Interlocking with the Bureau of Receipts, which controls revenues collected and to be collected, the Bureau of Disbursements becomes an absolute preventive of secret deficits to be passed on from one administration to another.

General Accounting System

These new accounting methods will be tied into a central accounting system that will supply periodically a true balance sheet of the city of Baltimore, not heretofore possible. An inventory and appraisal of all city property is in progress to establish detailed property ledger accounts. Not only fixed property but materials and supplies will for the first time be brought under this control.

A Central Bureau of Stores—the work of general storekeepers loaned by several large corporations, is being installed to take the place of the old method of departmental stores and store yards, of which there were 25. One central store-room and yard with six locations for sub-storage will be provided to carry and control materials and supplies and supplies for all city purposes. A saving of $175,000 a year will be available from this change.

A Bureau of Transportation to handle and maintain through a dispatcher, central garage and repair system, the $500,000 investment of the city in automobiles and trucks, promises a substantial saving by eliminating duplications of investment and retail methods of buying supplies and making repairs.

Consolidating and Centralizing Engineering Functions

An engineering survey developed the opportunities for consolidating and centralizing such functions scattered through many city departments. A number of engineering sub-committees worked out these plans which have now become operative in the new Department of Public Works headed by a chief engineer with a direct line of authority and responsibility over all such functions. Each unit of this department has its engineering head who is a member of the staff of the chief engineer and in this way the city not only gets the benefit of concentration and interchange of technical training and experience but the inter-use of equipment, labor and other factors heretofore assigned exclusively to a single city service. The Department of Public Works controls and operates in this centralized way the various services of water, sewers, highways, harbor, street cleaning, mechanical and electrical service, city plans and surveys, transportation, stores, buildings, and applying laboratories.

Time does not permit describing other plans for the consolidation and centralization of city functions, but the ultimate goal is a much more compact organization with the original 45 departments reduced about one-half in number.

NEW ROAD SPECIFICATIONS FOR MICHIGAN

By L. N. Jones, Assistant Construction Engineer, State Highway Department, Lansing, Mich.

(Editor's Note: This article by Mr. Jones is from a recent issue of "Michigan Roads and Pavements.")

Specifications for construction work of any nature are constantly changing. As new methods, new equipment and new standards of quality are adopted, specifications must be revised to meet the changing conditions. These changes occur so frequently that theoretically specifications should be revised not annually or biennially, but from month to month or even from week to week. Practically, of course, this is impossible as it would result in non-uniformity of work and cause confusion.

Realizing the importance of up-to-date specifications, the State Highway Department, during the past winter, has made a complete revision of the specifications for construction of roads and bridges. The Department Specifications for Road Construction, Edition of 1924, the Bridge Specifications, Edition of 1922 with subsequent revisions and the Contractors' Manual have been entirely rewritten and combined into a complete construction specification. In preparing the new specifications the standard outline adopted by the American Association of State Highway Officials was followed as closely as was consistent with the particular conditions and requirements of this State. The subject matter of the specifications has been covered under the following Division Headings:

General Provisions; Earth Work; Base Courses; Surface Courses and Pavements; Concrete, Steel and Timber Structures; Culverts, Retaining Walls and Masonry; Incidental Construction; Material Details.

The construction specifications will later be amplified by the addition of specifications for Road Maintenance, Bridge Design, and Construction of Movable Bridges.

Following the practice of several other states, each major division has been printed as a separate pamphlet so that specifications for any contract or for any class of work may be assembled by combining those pamphlets which apply. Future revisions may also be made more readily as any division or divisions can be revised and reprinted without changing other parts. In addition, a supply of complete construction specifications comprising the divisions named above have been bound in book form. The specifications have been printed in a smaller type than former editions in order to reduce the bulk of the volume. The pages have been set up in two columns so as to make the subject matter easier to read.

In revising the specifications, it has been the aim of the department to eliminate such provisions as are obsolete, contradictory or indefinite, to add new requirements where necessary to insure a high standard of workmanship or protect the interests of the State, and to arrange the subject matter in logical sequence and in a clear, concise form. As the State Highway Department specifications are used either wholly or in part by many counties, municipalities and other organizations doing construction work, the requirements have been made to conform as far as possible with the latest and the best practices. To this end the specifications of many other states, as well as the proposed specifications of the American Association of State Highway Officials, and numerous suggestions from manufacturers, contractors and engineers have been reviewed.

There are many minor changes in arrangement, wording and requirements which were made necessary by the thorough revision. Among the more important changes which affect the conduct of the work may be mentioned the following:

The provisions covering payment for increased and decreased quantities and extra work have been made more definite.

More rigid requirements for barricades, signs, lights and the protection of the traveling public have been imposed.

A specification has been added covering the preparation of a gravel or macadam surface which is to be used as a base course for bituminous concrete surface.

The number of grades of concrete used in various items of work has been reduced so that only three different mixes are specified. These mixes and the approximate proportions of each are: Grade A, (1:2:3½); Grade B, (1:2:½:4) and Grade C, (1:3:5).

Reinforcing steel for both pavements and bridges and culverts is governed by the same specifications which requires

steel of the structural steel grade or of intermediate grade meeting the cold bend test for structural steel grade.

The curing period for concrete pavement and concrete base course has been reduced from 14 days to 7 days and the thorough wetting of the covering material during this period will be insisted upon.

A double seal coat instead of a single seal coat is required on a bituminous macadam surface.

The specification for gravel for surfacing has been revised to require from 70 to 80 per cent retained on a ⅛-in. screen and the provision added that from 50 to 75 per cent shall pass a ½-in. screen.

Coarse aggregates for cement concrete have been classified into four classes designated by the maximum size of each, as 2-in., 1½-in. 1-in. and ¾-in. The previous grading requirements for the various coarse aggregates have been only slightly revised.

A tolerance in the finished thickness of concrete pavement has been prescribed and deductions from the contract unit price provided in case the thickness is less than required.

In the division devoted to bridge construction, specifications have been added covering removal of old structures, water-proofing of concrete surfaces, the construction of concrete, bituminous and asphalt block wearing surfaces on floors, and various minor items.

A complete specification covering timber, the preservative treatment of timber and the construction of timber structures, has been added.

The construction of all structures with a clear span of more than 20 ft. is now governed by the specifications for bridges.

The specification for concrete sidewalk has been revised to provide for a one-course construction.

The number of different grades of fine and coarse aggregate and bituminous materials used in the construction of bituminous surfaces has been reduced to a minimum.

The minimum amount of reinforcing steel required in reinforced concrete pipe has been considerably increased in the larger sizes of pipe.

Throughout the specifications confusing cross references to requirements under other items of work have been eliminated but, on the other hand, needless repetition has been avoided. The combining of the road and bridge specifications has also resulted in much less repetition. The new specifications are now available for distribution in either the pamphlet form or the bound volume. All work which has been advertised recently will be governed by the new specifications and it is believed that their use will greatly facilitate the efficient handling and proper control of the work.

OLD PAVEMENTS SURFACED WITH SECOND SLAB OF CONCRETE

(Editor's Note: The following article gives facts and figures on the resurfacing of old pavements with concrete. As will be noted, the examples are drawn from many states.)

Arkansas

Olive and Walnut Streets, in the city of Pine Bluff, were resurfaced in 1921. These streets were originally paved in 1910 and 1911 with wood block on a concrete base. The block would not stay in place. The commissioners of the paving district favored resurfacing with concrete and upon investigation learned that such resurfacing had been done successfully in other cities. Consequently, a contract was let in 1921.

The specifications called for a 4-in. thickness of 1:2:3 concrete, reinforced with wire mesh weighing 27 lbs. per 100 sq. ft. The base was irregular, however, and the surface is from 3 to 6 ins. in depth.

Before any fresh concrete was placed, the base was scrubbed clean and a thin cement and water grout was brushed over the surface. The new concrete was then laid immediately and struck off, tamped, finished and cured in the ordinary manner. Expansion joints were put in every 35 ft.

When inspected in 1923, this pavement was in fine condition. In fact, it has been so satisfactory that Pine Bluff property owners now prefer concrete for all their pavements.

Reference: Mr. Fred Bennett, Citizents' Bank Building, Pine Bluff, Ark.

California

Many California State Highways have been resurfaced from 1918 to date.

For a number of years, the standard surface for state highways in California was a concrete slab 4 ins. thick, mixed 1:2½:5. In 1917 this mixture was

changed to 1:2:4, and in 1920 the thickness was increased to 5 ins., and still later to 6 ins. The thinner slabs were considered as a base for some future application of wearing surface, but were to be used as unsurfaced concrete roads for an indefinite period.

Since traffic has increased to such a great extent, the State Highway Commission has conserved the investment in a number of miles of these old "Concrete Base" roads, by widening and resurfacing with concrete. Usually, an 8-in. concrete shoulder 2½ ft. wide has been built on both sides of the old 15-ft. width, and a new surface 4 ins. thick has been laid on top of the old slab, the new top being monolithic with the new shoulders. Reinforcing rods, ¼ in. round on 18-in. centers, are placed in the center of the resurface slab, transversely, and extend across the shoulders, In some cases, the new shoulder and resurface are laid on one side of the center line at a time, and traffic uses the other side until it can be turned onto the newly-paved side. Officials of the State Highway Department have expressed themselves as well pleased with the service being rendered by these widened and resurfaced roads.

Reference: R. M. Morton, State Highway Engineer, Sacramento, Cal.

County highways in Kern County, Cal., have been resurfaced from 1920 to date.

In 1920 approximately eight miles of concrete pavement were widened and resurfaced and in 1921 an additional three miles were given a second story in Kern County. The old pavements were 4 ins. thick and 15 ft. wide. A concrete shoulder was built on each side of the pavement 1½ ft. wide and 9 ins. thick, while the old pavement was resurfaced with 5 ins. of concrete resulting in a completed pavement 9 ins. thick and 18 ft. wide, the surface being monolithic with the shoulders. On none of this work was there any reinforcement used.

These pavements have been in use over three years and are standing up very satisfactorily under the heaviest kind of traffic. A traffic census of 12 hours tabulated 2,942 vehicles of which 292 were trucks of from 2 to 5-ton capacity, heavily loaded, mostly with pipe and machinery for use in the oil fields. The County Superintendent states that a 24-hour census would give about 4,000 vehicles using the road daily.

Reference: Paul E. Kressly, Consulting Engineer, H. W. Hellman Building, Los Angeles, Cal.

Highways in Orange County, Cal., have been resurfaced from 1919 to date. Since 1919 Orange County has resurfaced 24½ miles of the original highway system with a second story concrete slab. The minimum thickness of the second story slab has been 4 ins., but in many cases where the traffic is exceptionally heavy due to the extensive oil field development, calling for heavy loads of pipe and machinery, this thickness has been increased to 7 and 8 ins. with reinforcement.

The first resurfacing 2¼ miles in length was done in 1919, over a road built in 1914, 4 ins. thick, 18 ft. wide and with a 1:2½:5 mix. The subgrade was a sediment soil subject to overflow. Because of this unstable support the heavy traffic was breaking up the lean mix, 4-in. slab, and the 4-in. second story of 1:2:4 concrete was laid unreinforced.

One side of the road for a distance of 1¾ miles bears a very heavy traffic of loaded steel-tired wagons carrying 30,000 to 40,000 tons of sugar beets per year. Under this traffic four or five crowfoot cracks developed, and required repair. Upon the development of the Huntington Beach oil field the opposite side of the resurface received a tremendous traffic of trucks loaded with pipe, machinery and brick from Los Angeles. There is not a single instance of failure on this side of the road.

In later resurfacing reinforcement was added, and in some cases where a wider pavement was needed a shoulder was added on each side of the original concrete and made monolithic with the 4-in. top.

Most of the 24½ miles of concrete resurface is 4 ins. thick but in special cases 7 and 8 ins. of concrete have been added to the old concrete to carry unusually heavy traffic.

In addition to this work on county highways, some 10 or 15 miles of the state highway system in Orange County have been resurfaced by the California State Highway Commission. A 4-in. reinforced second story has been the usual plan, and the old highways 15 ft. wide have been increased to 20 ft. by the addition of 2½-ft. monolithic shoulders on each side. This work also has proved very satisfactory.

Reference: J. L. McBride, County Superintendent of Highways, Santa Ana, California.

Lincoln Road in Roseville, Placer County, was resurfaced in 1922.

This road has been resurfaced with a 5½ to 6-in. new concrete surface. The Original width was 15 ft. and an additional 2½-ft. strip has now been added on either side, making the total width 20 ft. The additional concrete on either side is 8 ins. thick. The yardage of this job totaled 13,141 cu. yds.

Reference: R. M. Morton, State Highway Engineer, Sacramento, Cal.

Idaho

The Cole Schoolhouse Road at the Fair Grounds in Ada County, Ida., was resurfaced in 1921. This road, built in 1913, was about 1½ miles long, 16 ft. wide and averaged 4 to 5 ins. thick. Part of the road was over swampy land in which water stood nearly the whole year, and the subgrade was a heavy clay soil.

When in 1920 the contractor widened the pavement to 18 ft. and laid a concrete resurface, all holes and edges were cleaned and painted with neat cement. Shoulders 1 ft. wide on each side were built and all holes were filled with new concrete flush with the old surface. A thin coat of Tarvia was spread over the entire base before the surface was laid.

The new surface 3 ins. in thickness was reinforced, and great care was taken in the selection of proper aggregate and in attention to construction details. The excellent condition of this road late in 1923 was instrumental in causing officials to select concrete for other highways in Idaho.

Illinois

Part of the Dixie Highway in Cook County, Ill., was resurfaced in 1923. This was between the towns of Chicago Heights and Steger. The new slab was 6 ins. of reinforced concrete.

The original pavement was built in 1917 and had a 1:3:6 concrete base 4 ins. thick, upon which was placed a 2-in. asphaltic concrete top. When it became necessary to resurface this pavement, the asphaltic top was loosened with a scarifier. The concrete base was in good condition, was swept clean, and the new concrete surface was placed upon it without further treatment.

The new surface was 6 ins. thick, a 1:2½:3 mixture and reinforced with Truscon expanded metal weighing 40 lbs. per 100 sq. ft.

No joints were provided, with the exception of a construction joint at the end of a day's run. The calcium chloride method was used in curing.

Reference: Clifford Older, Consoer, Older & Quinlan, 140 South Dearborn Street, Chicago, Ill.; R. R. Benedict, Assistant to Chief, Illinois Division of Highways, Springfield, Ill.

Indiana

The South Seventh Street Road at Terre Haute was resurfaced in 1918. The original pavement on this street was an asphaltic macadam built in two layers by the penetration process to a total thickness of 9 ins. Under heavy traffic the old surface developed waves and serious depressions. In 1918, the county authorities determined to resurface the entire pavement with concrete. Depressions and holes were first filled with concrete to produce a fairly uniform surface. Then it was flushed with water and a hot application of Tarvia XC made to form a complete separating coat between the old pavement and the new surface.

The specifications required 3 ins. of new concrete surface. On account of the irregularity of the old pavement even after the worst depressions were filled with concrete, the resurface layer varied from 3 to 5 ins. in thickness. The concrete was proportioned 1:1½:2½, the pebbles being under the 1¼-in. size. The amount of mixing water was kept at a minimum. Roller and belt were used to finish the surface. Truscon ribbed metal weighing approximately 42 lbs. per 100 sq. ft. was the reinforcement. Unprotected expansion joints filled with Elastite were installed every 40 ft. The pavement was cured by ponding.

The pavement is 18 ft. wide and lies on one side of the roadway. The interurban street car track occupies the other half of the street. The utmost care was taken throughout the course of construction to secure the best possible workmanship, and this care is reflected in the quality of the finished work. The pavement carries approximately 110,000 vehicles per day. After more than five years of heavy traffic, it. is in perfect condition.

West Wabash Avenue was resurfaced in Terre Haute in 1923. This street, which is a section of the National Road, is 1.24 miles long and was resurfaced with concrete in 1923. The old pave-

ment was a brick surface on a poor concrete base. It was built in 1907, had been in very bad condition for years, and had been patched with concrete and other materials until only a part of the original surface remained. Resurfacing was carried on under the direction of the Indiana State Highway Department.

The old surface was swept clean and the new concrete surface was placed directly upon the bricks without any attempt to make it adhere to or to be separated from them. The concrete was proportioned 1:2:3 and had a minimum thickness of 5 ins. with an average thickness of 6½ ins. It was reinforced with ⅝-in. bars spaced 4 ft. center to center each way and placed 3 ins. from the top.

The 28-ft. pavement was built half at a time so that traffic could be maintained. It was laid, finished and cured in the manner prescribed by the Highway Department for regular concrete pavements.

Massachusetts

Union Street in North Adams was resurfaced in 1922. This street was paved in 1903 with a 6-in. concrete base, 1-in. sand cushion and 4-in. vitrified brick top. By 1921 the surface was in bad condition and it was at first thought the bricks might be salvaged, turned upside down and relaid. The bricks proved to be very badly worn, some having less than one-half the original thickness, and because they had not worn uniformly the surface was very uneven.

After careful consideration of other types, including asphalt, brick and granite block, it was decided to resurface with cement concrete, partly on account of its reasonable cost and partly on account of the very satisfactory service given by some concrete pavements on other streets in the city.

In 1922 brick top and sand cushion were removed, the old concrete base swept off and thoroughly wet down just before the new concrete was placed. The resurface was 5 ins. thick without reinforcement, a 1:2:3 mixture, using screened gravel as coarse aggregate.

The street had a car track on wooden ties of 9-in. girder rails, Trilby type, which needed reconstruction. The rails were taken up and some of the concrete base had to be removed, after being broken by pneumatic hand drills. The old ties were left in position, being low enough to allow "International" steel ties to be laid on top. The new rails were standard "T" rails. The resurfacing was done on half the street at a time, not including the car track area so that a minimum of inconvenience to traffic was experienced. The car track was paved last.

The contract price of the resurfacing was $2.01 per sq. yd., which included the removal and disposal of the old bricks and removal of the 1-in. sand cushion. The extent of the improvement was about 30 to 34 ft. total width, 900 ft. long. This resurfacing was done during 1922.

North Adams is an important railroad and manufacturing town of about 22,000 population. Union Street carries quite heavy traffic in the manufacturing district.

Michigan

The Grand River Road in Wayne County was resurfaced in 1916. A section of this road was paved with concrete in 1910. The pavement was 16 ft. wide and 6½ in. thick, a two-course pavement somewhat irregular in finish and built with inferior materials and workmanship. The heavy traffic made the surface so uneven as to be unsatisfactory. In 1916 the county authorities decided to resurface with concrete and at the same time widen the pavement to 20 ft. The edges of the old pavement were broken down with sledges, and concrete shoulders 2 ft. wide and equal in thickness to the old pavement were built on each side. All serious holes and depressions in the old pavement were filled with new concrete to produce a fairly uniform surface. After this had hardened, the surface was cleaned with water and the street brooms, and while still wet, a mixture of Tarvia AX hot was applied, spreading in a very thin layer on the wet surface and forming a thin bituminous separating coat over the entire old surface and the new shoulders.

A concrete resurface was then applied, having a total thickness of 3 in., proportioned 1 part cement 1½ parts sand and 2½ parts trap rock graded in size from ¼ to 1 in. No 26 triangle mesh reinforcement was used in the new wearing surface. An attempt was made to place expansion joints in the resurface exactly over the joints in the old pavement. The joints in the resurface layer were protected with soft steel armor plates. Later developments indicate that the joints in the resurface

may not have been placed exactly over the joints in the old pavement. The work was in service seven years and was regarded by the authorities and those who live on the road as a complete success. A few transverse and longitudinal cracks appeared but were repaired with tar exactly as concrete pavements laid in the usual manner are repaired. They gave no indications of raveling or disintegration. The road carried a traffic averaging approximately 2,500 vehicles per day including many heavy trucks.

In 1923 this entire pavement was torn up to permit construction of a double track electric railway in the center of the right of way. The pavement will be replaced by two new sections of concrete, each 18 ft. wide on either side of the new car tracks.

Reference: E. N. Hines, chairman, Wayne County Road Commission, Detroit, Mich.

Gratiot Road in Wayne County was resurfaced in 1917. This road was originally paved in 1910 with concrete pavement known as Dolarway. The proportions of the concrete in the original pavement were approximately 1:2½:5 and, owing to the inferior character of the materials and the comparatively poor workmanship, the heavy traffic abraded the surface to such an extent that it required resurfacing.

In 1917 this pavement was resurfaced with a layer of concrete 4 in. thick and reinforced. The details of construction for the resurface were almost the same as were used on the Grand River Road resurfacing except that as the old Dolarway surface had a thin bituminous wearing coat it was thought unnecessary to lay a separating bituminous coat as was done on the Grand River road. The pavement was widened to 20 ft. and the concrete on the new shoulders was separated from the concrete in the resurface layer by means of sheets of tar building paper laid flat.

In 1923 traffic and the adjacent development required a wider pavement, and a 10 ft. strip of concrete was added to the existing resurfaced pavement. A 19 hour traffic census showed 19,651 vehicles passing a point on this road. Under this extremely heavy traffic the resurfacing is still even and an excellent pavement.

Reference: E. N. Hines, Chairman, Wayne County Road Commission, Detroit, Mich.

Missouri

Water Street, Cape Girardeau, was resurfaced in 1916. This street was originally paved with wood block on a concrete foundation in 1914. During the spring of 1916 a flood carried away the wood block surface and it was replaced with a new concrete surface. The concrete base which was very rough and poorly constructed was prepared to receive the concrete surface merely by cleaning with brooms and flushing with a hose stream. The concrete resurface was made 4 in. thick using washed river sand and crushed limestone proportioned 1 part cement, 1½ parts sand and 3 parts stone. No reinforcement was used. This pavement was not in first class condition in 1923, because it did not have the quality of workmanship on the wearing surface which has been given the latter work.

Several other streets have since been resurfaced using more care in evening up the concrete base, and reinforcing the surface with 36 and 40 lb. mesh. Main Street 4,000 sq. yds. and Independence Street 1,600 sq. yds. built in 1921; Water Street extended 604 sq. yds. and Broadway 628 sq. yds., built in 1922; and 2,500 sq. yds. of concrete between the street car tracks on Broadway were built in 1923. This work is remarkably free from cracks and is holding up very well.

Reference: Louis Wittmor, Superintendent of Streets, Cape Girardeau, Mo.

Jefferson Street, Kirksville, was resurfaced in 1917. This street was originally paved with a 5 in. cement concrete foundation and a 2 in. bitulithic wearing surface. Maintenance of the original pavement was neglected and it was subject to very heavy coal hauling traffic from nearby mines consisting of 3 to 5 ton loads of coal hauled in narrow steel tired farm wagons. In 1917 it was necessary to remove the bituminous surface from the concrete base, and resurface with cement concrete.

The concrete base was first thoroughly cleaned by sweeping with brooms and was then flushed with a hose stream. Dry cement was sprinkled over the wet surface and a layer of concrete, mixed 1 part of cement, 2 parts sand and 3 parts trap rock, was placed 4 in. deep. A 45 lb. steel mesh reinforcement was placed in the center of this resurface layer. The new surface was finished by rolling, belting and the use of a wood

float. Expansion joints were formed in the resurface at intervals of 40 ft.

The original pavement had a combined concrete curb and gutter, 1½ ft. wide from the back of the curb to the edge of the gutter. As this was in excellent condition, it was not removed when the resurfacing was done. The width of the resurfacing between the gutter lines was 21 ft. The 4 in. resurface was left 2 in. higher than the surface of the old gutter. The new concrete was finished to a square edge, with a vertical drop of 2 in. to the plane of the gutter. Traffic has worn this square edge to a somewhat irregular, rounded contour, otherwise the pavement was reported in first class condition in 1923. It carries the same traffic that destroyed the original wearing surface and had not one cent spent for maintenance in six years of its life.

Reference: Ben Crabtree, City Engineer, Kirksville, Mo.

West Market Street in Savannah, Mo., was resurfaced in 1915. This street was originally paved in 1914 with a patented type of asphaltic wearing surface on a cement concrete foundation. Due to some improper construction, the surfacing disintegrated within a few months following construction, and during 1915 the asphalt was removed and replaced by a concrete wearing surface 2 in. thick at the sides and 3 in. thick at the center. The concrete was mixed in the proportion of 1 part cement, 2 parts sand and 3 parts Joplin chats. A light steel mesh reinforcement was placed approximately in the center of the resurface. The concrete foundation was prepared to receive the new wearing surface merely by brushing with street brooms and flushing with a hose stream. The resurfacing was finished with wood floats according to the method in common use at that time. It is reported in first class condition today, although the character of workmanship was not such as to produce the best riding surface.

Nebraska

A section of the Lincoln Highway in Dodge County was resurfaced in 1922. In 1913, Dodge County built 1,310 ft. of 18 ft. concrete pavement over a nearly impassable section of sand road. The subgrade had at one time been the dumping ground. None of the details of this construction are available.

This pavement had settled, worn and cracked so badly by 1922, that resurfacing was necessary. The average thickness of the resurface was 6 in. and proportions were 1 of cement to 3 of gravel. The pavement was broomed and deep holes were filled ahead of the concreting. Wire reinforcement was put in the concrete over the holes that had been filled.

New Jersey

North Main Street, Phillipsburg, was resurfaced in 1922. Originally this street was paved with brick on a concrete base. When in 1922 it became necessary to repave the street concrete was selected as the most suitable material. A 5½ in. surface of 1:1½:3 concrete was built on the old concrete base, reinforced with 65 lbs. of wire mesh per 100 sq. ft. The work was completed in 1922 and when inspected in January 1924 was in perfect condition. The resurface is 2,500 ft. long, 12 to 20 ft. wide.

Reference: Evan James, Commissioner of Streets, Phillipsburg, N. J.

New York

The new Scotland Road at Slingerland in Albany County, was resurfaced in 1916. A 7 in. bituminous macadam pavement on this road, built in 1910, needed rebuilding in 1916, and was reconstructed with a concrete top 3 in. thick. The upper course of old macadam was used to retrim the shoulders. Early in 1924 the road was in very good condition although there was slight scaling not sufficient to affect the riding quality of the surface.

West Fulton Street in Gloversville was resurfaced in 1921. In 1921 it was necessary to replace the old surface of West Fulton Street. A concrete wearing surface was placed directly on the old concrete base, after it had been cleaned and wetted. The new surface consisted of 1:2:3 concrete 5½ in. thick and reinforced with welded wire cloth weighing 32 lbs. per 100 sq. ft. placed 2 in. below the surface. Longitudinal expansion joints consisting of prepared strips of asphaltic tar were placed along the curbs. Transverse joints were placed at 35 ft. intervals. No joints were visible in the old foundation.

Concrete was placed in two strips, half the width of the roadway and the resulting construction joint was bonded by lapping the reinforcement 12 in. In order to do this, the form used along the center of the street had to be in two parts, one above the other, between which the reinforcement extended. Two planks were used, the lower being a 3 by 6 in. plank and the upper 2 by 6 in. The lower plank was laid flat on the old foundation. Concrete was then placed to the top of

the plank and the reinforcement was spread over the concrete and extended across the center form to provide the 12 in. lap. The upper plank was then spiked to the lower and the remainder of the concrete placed over the reinforcement. After the concrete was struck off, it was floated by hand from a bridge which spanned the pavement. The concrete was cured by covering with a 2 in. layer of earth which was kept wet for ten days.

The work was begun on the 8th of September, 1921 and was completed within 8 days during which time and for ten days thereafter, no traffic was allowed on the streets.

Bridge Street in Oswego was resurfaced in 1919. Bridge Street is the main street through Oswego, and is a connecting link of the Roosevelt Highway, being the main line of travel connecting the Thousand Islands, Rochester, Buffalo, Syracuse, Watertown and New York City. The original surface was 2 in. black top with a 1 in. binder on a 6 in. concrete base, was laid in 1898, gave excellent service, but by 1919 had become badly rutted and needed replacement.

The street resurfaced is 54 ft. wide and has a single track trolley line down the center, which was relaid at the same time the adjoining pavement was resurfaced. After the old bituminous surface had been removed the concrete base was swept clean, wetted and brushed with cement mortar. A few places where it was broken were rebuilt to the same level. A new surface of reinforced concrete 4½ in. thick, mixed 1:1½:3 was laid and finished, first on both sides of the track and finally, the 9 ft. track strip. Special attention was given to making the mixtures uniform and to curing the concrete properly.

Soon after construction 66 water trenches had to be cut through, and the surface repaired after only one month's settlement. The patches were carefully done, reinforced with 120 lbs. per 100 sq. ft., 2 in. from the bottom of the slab.

Since the resurface was laid, in 1919, the traffic has increased 50%, with no resulting damage to the pavement. The city officials are convinced of the merits of this type of construction.

Water Street and Central Avenue, in the City of Peekskill, were resurfaced in 1923. Water Street and Central Avenue were paved in 1901 with vitrified brick on a 6 in. concrete base. Due to the increased traffic of a live and growing community, the pavement became badly worn by 1918. Concrete patching gave good service; but as the pavement developed more holes, due to heavy loads being hauled to and from an iron foundry on Central Avenue it was decided to resurace both thoroughfares with concrete.

Finally in 1923 the old brick was broken out with crowbars and removed. The sand bed was then scraped off as close to the old concrete base as possible. No brooms were used but the old base was thoroughly wet down just ahead of the placing of the new concrete. Upon the wet base, mats of ½ in. steel bars spaced 12 ins. transversely and 20 ins. longitudinally were placed. Over this reinforcement, a 5 in. thickness of 1:1½:3 concrete was placed, using limestone aggregate graded up to 2½ ins. in size. By the use of hooks, the reinforcement was then pulled half way up the thickness of the new top. Prepared expansion joints ⅜ in. thick were spaced 60 ft. apart and along the curbs.

Water Street, 24 ft. wide, has a car track in the center. Finishing was done with a screed resting on the rails and curb and a belt was used to finish the surface. Expansion material was placed along the tracks. Central Avenue is 44 ft. wide. The pavement was laid half at a time. A screed was worked roughly over the surface, and the final finish was given with belt and hand floats.

The Village Board and Trustees are all well pleased with the results.

Union Street in Schenectady was resurfed in 1909. Union Street, one of the finest residence streets of the city, had been paved with 3 ins. of asphalt on a concrete foundation. This surface had worn so by 1909 that it was only 1 to 1½ in. thick and it was decided to build a 10 ft. wide strip of concrete down the center of the street. Accordingly, the center strip of asphalt was cut out for 460 ft. and replaced with 1:1½:3 concrete, 3 in. thick to within 18 ins. of the edge, and from that point sloped to 1 to 1½ ins. to meet the surface of the asphalt. The surface was grooved to give traction on the 6% grade and at the grooves the concrete was approximately 2½ ins. thick.

In 1917 at the age of 8 years this surface was giving good service although slightly worn, and showing a few breaks. After 12 years of service the breaks had so increased as to warrant taking up the old concrete. It was replaced by granite blocks.

Reference: George I. Howard, City Engineer, Schenectady, N. Y.

Ohio

Warsaw Street in Toledo was resurfaced in 1913. During the fall of 1912 a concrete pavement was built on this street, two blocks of which were damaged by frost. In the spring of 1913, the damaged surface was sprinkled and kept in a moist condition until the contractor could resurface. The original concrete was very carefully cleaned to remove any loose particles and before the resurface was placed was sprinkled with dry cement which was worked up with wire brooms into a neat cement grout. The concrete for the new surface was mixed in the proportions of 1 part cement, 1½ parts sand, and 2½ parts crushed rock ranging in size up to ¾ in. The thickness of the resurface varied from barely 1 in. at the margin to 2 ins. at the center, the pavement being 26 ft. wide. A very light wire mesh was placed in the resurface approximately in the center. Notwithstanding the extreme thinness of this resurfaced section, the work was reported to be in first-class condition in 1923.

Reference: L. T. Owen, City Engineer, Toledo, Ohio.

Oregon

The Multnomah County Line to Newberg Highway, in Washington and Yamhill Counties, Ore., was resurfaced in 1923. This highway, 15.7 miles long, was built in 1917-1918 with a 2 in. standard bitulithic top on a 4 in. crushed rock base, 16 ft. in width, with a 2 ft. macadam shoulder on each side. Under a traffic of nearly 900 vehicles a day over 100 of them trucks and 65 of the trucks over 1½ tons weight it became necessary to reconstruct this section; 3.64 miles on hills were rebuilt with concrete averaging 7.7 ins. in thickness, and the remaining 12.06 miles were covered with black binder course 1½ ins. tnick with 2-in. wearing surface of bituminous concrete.

Work was begun in October, 1922, shut down for the winter and completed in May, 1923. Slab lengths were 30 ft., separated by ¾ in. prepared joints, and laid with longitudinal center joints. On most of the pavement, where no detours were possible portions of the pavement were laid half at a time. On this two strip work ½-in. reinforcement bars were placed 6 ins. from the edges and ends of each slab, and ½ in. tie bars 3 ft. long across the center joint. This pavement was in splendid condition in January, 1924.

Texas

Lee Street in Greenville, Texas, was resurfaced in 1923. Lee Street was paved in 1911 with 3 in. wood block on a 4 in. concrete base. When it became necessary to resurface this street, the wood block was removed and replaced with a concrete wearing surface. The actual thickness was slightly increased to give a minimum thickness in the center of 8 ins. The mix was a 1:2:3 concrete and wire mesh weighing 28 lbs. per 100 sq. ft. was placed 2 ins. from the surface. Half inch elastic expansion joint was constructed in the center of pavement. Transverse joints ¼ in. wide were constructed on each side at intervals of 25 ft. These joints were staggered. The slab was covered with dirt and kept wet for 2 weeks. Traffic was not allowed on the pavement for 28 days after completion. At the end of 1923, this street was in excellent condition.

Washington

Fairhaven Street, in the town of Burlington, Wash., and part of the Pacific Highway, in Skagit County, were resursurfaced in 1921 and 1923. In 1921 a contract was awarded for 5 in. concrete resurfacing of an old Dolarway pavement laid about 1912. Part of the pavement was within the city limits and part outside on a county road. On July 5, 1921, the county awarded 5,800 sq. yds. of 5 in. resurface over the old Dolarway pavement on Garl Street, part of the Pacific Highway leading through Burlington. On the same day the city of Burlington awarded 1,436 yds. of 5 in. resurface work on Fairhaven Street which leads from Garl Street. The pavement was laid in the usual manner. Expansion joints were placed at 25 ft. intervals.

In March, 1923, the city of Burlington made a further award of 1,039 sq. yds. This was for a 5 in. concrete top over the Dolarway pavement.

Reference: Robt. E. L. Knapp, County Engineer, Mt. Vernon, Wash.

Everett Avenue, in the City of Everett, was resurfaced in 1923. Everett Avenue was originally a 20 ft. wood block paving on a 5 in. concrete base. The wood block was broken up with a tractor and plough, and removed by trucks. The old concrete base was cleaned with a street sweeper. The resurface, averaging about 6 ins. thick on the entire job was then placed. One-

quarter inch transverse expansion joints were placed every 20 ft., making the slabs 20x20 ft.

The yardage laid on this improvement was 5,102 sq. yds. placed July, 1923.

Hewitt Avenue, the principal business street of Everett, was originally paved 68 ft. wide with 5 in. wood block on a 5 in. concrete base.

When it needed rebuilding early in 1922 the old base was found to be in excellent condition although the grade was not very uniform. Due to this unevenness the concrete resurfacing varied in thickness from 4 to 6 ins. Wherever the resurface was less than 5 ins. thick, ⅜-in. street bars were used in preference to wire mesh. One-quarter inch expansion joints were placed every 25 ft. The new concrete was mixed in 1:2:3: proportions and laid in one course. After six months service late in September, 1923, one crack had developed due to the expansion, on an extremely large slab of an intersection. The city part of the pavement 16,100 sq. yds. was awarded in 1922 and the street railway portion for 21,400 sq. yds. was awarded May 14, 1923.

The Street Railway, later extended the resurfacing work, and in July, 1923, awarded a contract for 2,000 sq. yds. of 5 in. concrete.

Reference: S. E. Paine, City Engineer, Everett, Wash.

Union Street in Seattle was resurfaced in 1923. Contract for resurfacing with 5 in. of concrete three quarters of a mile on Union Street was awarded in 1923, work commenced June 14,1923 and the street opened to traffic July 20, 1923.

The original surface was of brick placed upon a 6 in. concrete base and built in 1903. Heavy and continuous traffic which increased each year, caused the old surface to become badly worn.

Union Street is one of the heaviest traveled streets in Seattle. The intersection with Third Avenue, where the Federal Building and Post Office is located, is the busiest corner in the city. It was necessary to complete and open the pavement in the shortest possible time, and maintain a traffic way for the heavy mail trucks to and from the Post Office, so day and night crews were employed.

All of the preliminary work necessary for rearranging the car tracks was done between the hours of twelve midnight and six in the morning. No concrete was placed during the night shift, this time being used in taking up the old surface, delivering materials and cleaning the old concrete base, which was found to be in excellent condition after 20 years of service.

The new surface was designed for 5 ins. in thickness, but the irregularity of the base surface brought the average thickness to something like 6 ins. Concrete was mixed 1:2:3½. Expansion joints were placed at 20 ft. intervals, staggered 2 ft. at the center joint, on that part of the street which did not have car tracks.

On the roadway section, two large mixers were started, one on each end of the job, and the work of placing the concrete on each side of the track zone required only 4 days. As the concrete was placed during the warmest part of the summer, damp burlap was placed over the fresh concrete as soon as it had set sufficiently to avoid marking. Curing was with automatic sprinklers. At street intersections where cross traffic was absolutely necessary, the concrete was covered with a 6 in. layer of damp sand over which a plank roadway was placed.

The pavement is a fine job, in excellent condition, and carries some of the densest and heaviest traffic of the city.

Reference: W. H. Tiedeman, Assistant City Engineer, Seattle, Wash.

Wisconsin

The Janesville Plank Road in Milwaukee County was resurfaced in 1917. A section of the Janesville Plank Road, Milwaukee County, Wis., was originally paved with concrete in 1912. The original concrete was made of pit run aggregates which were dirty and very poorly mixed and the concrete deteriorated after four years of traffic to such an extent that reconditioning was necessary.

The original pavement was 18 ft. wide and 8 ins. thick at the center. The County Highway Commissioner in 1917 determined to recondition a 4,000 ft. section of this old pavement with a new concrete surface, at the same time widening the pavement to 19 ft.

The tar used for filling joints and cracks was first removed, the surface swept with stiff brooms and flushed with a hose stream. A layer of neat cement, dry, was first spread on the wet surface to a depth of ¼ in. The concrete mixture for the resurface was placed on this layer of neat cement which absorbed moisture from the wet surface underneath and from the new concrete above forming what tile setters call "butter" for fastening tile to a wall or floor.

A 1:2:3½ concrete was used, the aggregates being clean sand and crushed granite under 1 in. maximum size, but the proportions were slightly varied when necessary to secure the densest concrete.

Thirty pound steel mesh reinforcement was placed 2 ins. below the final surface. The new concrete has a minimum depth of 3 ins., extends beyond the sides of the old pavement 6 ins., and is carried down to the bottom of the original pavement forming a cap over the top and sides of the old pavement.

A traffic census taken on five different days during July and August, 1921, showed an average of 935 vehicles daily between the hours of 8 a. m. and 5 p. m. Of this number, an average of 218 daily were trucks.

The riding surface is not as even as could be desired. There are a few cracks, both transverse and longitudinal. At the intersections of these cracks there are a few places where wear has occurred, causing a depression. Fully 90 per cent of the section is in excellent condition. Although originally undertaken as an experiment, the county authorities consider the investment a success.

CAMP AND OUTDOOR SANITATION

(Editor's Note: Following is the full text of the report of the Committee on Camp and Outdoor Sanitation to the Conference of State Sanitary Engineers, June, 1926. The committee personnel is as follows: J. A. Childs, C. R. Fox, E. L. Filby, C. G. Gillespie, J. M. Helper, H. B. Hommon, D. E. Kepner, Jane H. Rider, R. C. Sweeney, S. W. Tay, and E. S. Tisdale, chairman.)

Reference to the transactions of 1924 and 1925 conferences of State Sanitary Engineers at Cincinnati, Ohio, and Louisville, Kentucky, indicates that the subject of camp sanitation is becoming increasingly important in the eyes of State health officials. The subject was discussed from different angles at both these conferences. Following the 1926 conference a committee on "Camp and Outdoor Sanitation" was appointed to study this subject and bring a report to the 1926 conference. Resignation of W. H. Dittoe, committee chairman from the State Service of Ohio during 1926, brought about some interruption in the formulation of a report. Nevertheless, a study of the subject by the committee members has been made and the following report deals with the major points of tourist and resort camp sanitation and its administration by State Health Departments.

Basis for Report

Information on the present status of camp sanitation was sought by a series of questions addressed to the State Sanitary Engineers. By this means the committee obtained a cross section of the county as a whole. Camp sanitation control is demanding greater attention of State health authorities year by year.

The 20th Century Nomads

Certain states are exceedingly high in the number of outdoor camps. California had 400 camps inspected in 1925 and in this same year Maine had 700; New York 369 and Florida 225 camps receiving inspection by State Health Departments. Also the states which border on the Great Lakes and Mountain country show a relatively high intensity of outdoor and tourist camps. From California to Maine and from the Great Lakes to Florida, streams of auto tourists—the 20th century nomads—are constantly on the move as one season succeeds another. The tides of humanity are surging from east to west and from north to south along the main auto routes of this country with the seasonal temperature changes. Ever increasing numbers of outdoor tourist camps are catering to these traveling automobilists in their Rolls-Royces and Fords.

Highway Water Supplies vs. Railroad Water Supplies

It seems to your committee that the establishment of safe water supply points along the main traveled highways of the several states is no less important than maintaining safe railroad water supplies in interstate travel with respect to limiting the spread of water borne diseases. The Sanitary Engineering Divisions of State Health Departments have for over ten years been cooperating with the U. S. Public Health Service in safeguarding and certifying the railroad drinking water supplies. Through this cooperative program safe water is furnished to travelers on the railroad lines. The same general scheme, that is, making available safe water supply, may be followed with advantage along the main auto routes throughout the country.

Localized Travel Within States to Summer Camps Greatly Increasing

In addition to the long swings across the country in which tourist camps fig-

ure prominently, there is a more localized migration of people from the large cities to the summer camps of their own states. The lakes, woods and mountains are now accessible in a few hours drive by auto. This has resulted in large areas becoming more densely populated by Boy Scout, Y. M. C. A., municipal recreational, religious and university extension type of summer camps.

Magnitude of Problem

In 35 states which answered our brief questionnaire on camp sanitation, over 3,000 camps showed definite inspection by state authorities during 1925. In many cases bad conditions of water supply and excreta disposal prevailed. It appears likely that each of these camps were used by at least 500 different people during the season, giving us 1,500,000 persons utilizing camps in the 35 states. Many of the states from whom answers were not received by the committee are typical resort states and it does not appear unreasonable to estimate a total of 2 to 3 million persons stopping at summer camps of one type or another during the camping stason.

1925's High Rate on Typhoid and Intestinal Diseases

Your committee has had no opportunity to conduct a study into the cause for the unusually high prevalence of typhoid fever throughout the whole eastern and southern sections of the United States during the summer and fall of 1925. It appears probable, however, that the unusual drought which forced people in the affected states in large numbers to go to water supplies not generally in use and whose quality was questionable, was a large factor in this typhoid increase. If people in large numbers traveling from one section to another—really a great seasonal nomadic movement—use questionable water supplies as they travel it is quite likely the typhoid rates in the states will increase materially.

Control of Camps by State Regulation

Some general tendencies stand out prominently from an examination of the classified data submitted from the various states. Of the 35 states answering the questionnaire of our committee as to duties and control of camp sanitation, 30 states have enacted special rules and regulations to govern outdoor camps. In nearly all cases these regulations have been drawn up in 1925 and 1926 indicating how recently these problems of camp sanitation have arisen to a magnitude where state authorities are taking cognizance of them.

A marked unanimity of opinion was noted among the sanitary engineers with reference to what they considered the most important phase of sanitation in these outdoor camps, safe water supplies and safe sewage disposal being the two main essentials demanded.

For the most part in the 35 states submitting data, special engineers or sanitary inspectors are employed during the summer months to supervise the camp sanitation at outdoor camps. However, in some cases the regular engineers are used although the nature of the work is such that special inspectors can usually handle it.

Decentralization Program Recommended

A further study of the data submitted to the committee members indicates that the question of administration of the regulations governing camps may most advantageously be handled through cooperation of state and local health officials. The states most successful and oldest in point of experience on camp sanitation control state that as far as possible decentralization of inspection work is wise. The Sanitary Engineering Division of the State Health Department should give general guidance to the work furnishing rather detailed regulations to assist local health officers. The actual work of inspection as far as possible should be delegated to the city, county or district health officials and their local organizations. Wherever sanitary engineering problems are involved the State Department of Health should assist in solving them.

State Guidance and Official Sanction of Camps Welcomed

Finally, with regard to the general trend of camp sanitation work in its relation to the public as a whole, it is noted that the approval of State health authorities is a goal much strived after by outdoor camp operators and owners. Moreover, the public in general have high faith and trust in the sanction given to camps and water supply points by State sanitation officials. These matters should be borne in mind in developing a standardized program of activity in the different states. There appears to be a definite trend to equip outdoor and tourist camps more completely as they cater to the convenience, comfort and safety of the patrons. By encouragement and assistance lent to good camps it is believed the poorer ones will gradually drop out.

State authorities in view of this trend of improvement in development should set a rather high standard for camp sanitation equipment. Specific evidence along this line is the requirements for flush toilets in Florida tourist camps and the building of recreational halls, shower-baths, laundries and swimming pools in the California outdoor camps.

General Specifications for Regulations on Camp Sanitation

Examination of the regulations governing camp sanitation from the several states shows a general agreement in their form and contents. They include these eight points:

1. Definition of a camp.
2. Submission of plans and issuance of permit.
3. Safe water supply.
4. Safe sewage disposal.
5. Sanitary garbage disposal.
6. Proper drainage.
7. Capable management.
8. Penalty clause.

These 8 points have been expanded to specify what the detail regulations should set forth:

Specifications for Regulations Governing Camp Sanitation

Reg. 1. A clear cut definition of what constitutes a camp in the eyes of the State Health Department should be set down so that a definite understanding is given of the camps which must conform to regulations of the department.

Reg. 2. Notification shall be given of proposed camp, information filed describing same and permit issued after inspection by local or State health officials shows that regulations on camp sanitation have been complied with.

Reg. 3. Definite provision must be made for securing a safe water supply for the camp. The supply may be obtained from dug or drilled wells, springs adequately protected, or from a pressure water system. It must be adequate, so located as to be convenient and in quality conform with the State standards for safe drinking water. No unsafe water supply is allowed on the camp grounds.

Reg. 4. Safe and satisfactory disposal of sewage wastes must be provided. Listed in order of preference are flush toilets with septic tank and sub-surface irrigation for safe disposal of liquid contents. Chemical toilets may be used to advantage with suitable care for proper installation and maintenance. Properly located sanitary pit privies that are fly-tight and comply with State requirement may be used. They must be maintained in a clean and neat condition at all times.

Reg. 5. Disposal of garbage wastes must be made daily either by hauling away, incineration or burial. Conveniently located metal cans with tight fitting covers should be used as agencies in collection of rubbish and garbage about the camp.

Reg. 6. The location of the camp must be such that good drainage is assured. Swampy ground should not be tolerated in or near the camp.

Reg. 7. A responsible custodian must be charged with the care and upkeep of the camp who will see that the regulations of the State are complied with.

Reg. 8. A penalty clause should be included so that the enforcement of the camp regulations may be clearly set forth.

The idea of allowing the posting of an "Approved Camp" sign is advanced by certain State Health Departments as a means of raising the standard of the tourist camps particularly. Florida had 225 "Certified Camps" in 1925 and the "Approved Camp" sign is being used in Ohio.

Certification of Highway and Tourist Camp Water Supplies

The novel scheme which was inaugurated in Ohio in 1924 and called the "Seal of Safety Campaign" for stimulating improvement over the State as a whole in semi-public water supplies, has been found practical. The appeal to the traveling public of the service rendered has been rather remarkable. In October, 1925, a summary of the accomplishments in 40 states was presented before the American Public Health Association by Mr. Earle Waterman, Professor of Sanitary Engineering, University of Iowa, with respect of somewhat similar plans adopted by the various states to protect highway water supplies. His paper showed that approximately 50 per cent of the states had at that time under way some definite program to safeguard the semi-public water supplies along the main highway routes. Cooperation between State Health and State Highway Departments with respect to the erection of standard signs is practical. State and local automobile associations welcome the opportunity to place signs at certified water supply points.

Standard Highway Sign Adopted by Bureau of Public Roads

This year a standard road sign has

been adopted by the Bureau of Public Roads in the Federal Government and State Highway Departments are expected to accept this as a standard. The sign is of heavy metal, measures 24x14 ins. with black letters on a white background. Across the sign in large letters appears the words "Drinking Water" and in the lower corners are spaces for certificates of purity of each state. Apparently it is proposed that this sign should be erected as near the water supply as possible on the highway right-of-way. The committee feels that such a sign should carry but one certificate of purity marker instead of the two specified and that it would be preferable to have on the sign the words "Safe Drinking Water" and also indicate the name of the State Department of Health certifying the supply.

Practical Methods of Certification

Methods used in the various states for certifying highway water supplies vary to a considerable degree. Metallic discs, small tin signs like auto license plates, copper plates, paper certificates and other insignia are being used. The field bacteriological testing laboratories with advance and follow-up men to post safe supplies has been found to give satisfaction. It appears to the committee that a preliminary survey to select the water supplies possible for certification, the collection of samples from satisfactory points, the elapse of the necessary time interval for necessary improvements, and the re-survey to post the certificates of purity is the most logical method of procedure.

The committee feels strongly that the sanitary survey should indicate (1) an absence of all sources of pollution about the supply; (2) that construction should be such that no chance pollution at the supply can occur; (3) that the quality of water conform to the State standard for safe supply. The adoption of the scheme of placing the sign directly at the supply and attaching the certificate of purity—a metal marker—on this steel sign will give standardization to this whole scheme if it is considered a safe and practical procedure. It is possible, of course, for unscrupulous persons to remove the sign and transport it to some other supply, but it does not appear likely that this would be done where the certificates of purity are serially numbered, attached by State officials, and checked up periodically by the local and State health authorities.

Conclusions of Committee on Camp Sanitation

1. Camping out of doors in the United States has increased to a degree where several millions of people annually spend a part of the camping season living out of doors and traveling from one section of the United States to another by automobile. Maintenance of sanitary camps should be enforced by State health authorities.

2. Semi-public water supplies along the main arteries of highway travel throughout this country should receive the attention of State Health Departments working on a coordinated uniform plan of certifying and posting the safe water supplies for travelers. It appears likely that safe-guarding roadside water supplies will be a beneficial step in holding down the typhoid rate within the states.

3. Special regulations on camp sanitation enacted by the State Health Departments are the usual procedure to set up certain minimum standards of camp sanitation in the states. These appear to be fairly uniform and the principles generally agreed upon.

4. A decentralized program for administering camp sanitation regulations appears wise. Local health officials should be furnished with state regulations, sufficiently detailed to carry through the inspections.

Recommendations

1. That a uniform highway "Safe Drinking Water" sign be agreed upon by the Conference. The committee feels that some changes may be desirable in the standard "Drinking Water" sign adopted by U. S. Bureau of Roads.

2. That Regulation on Camp Sanitation conforming to the general specifications set forth in the body of this report be considered for adoption in those states which do not at present supervise camp sanitation.

3. That a decentralized program appears to be the most logical and economical way of administering camp sanitation control. State regulations are thus set up as a standard and local health organizations assist in carrying them out.

PROGRESS IN WATER SUPPLY AND PURIFICATION

(Editor's Note: Following is the full text of the report of the Committee on Water Supply and Purification to the

Conference of State Sanitary Engineers, June, 1926. Members of the Committee are: R. D. Bates, New York; E. W. Campbell, Maine; H. R. Fullerton, Tennessee; R. F. Goudey, California; Richard Messer, Virginia; H. E. Moses, Pennsylvania; J. H. O'Neill, Louisiana; F. H. Waring, Ohio; and H. W. Streeter, U. S. Public Health Service, chairman.)

In the progress report of this committee submitted to the Conference last year, four outstanding developments in the field of water supply sanitation were recorded. First of these was the issuance of a final report of the Committees on Official Water Standards of the U. S. Treasury Department; second, the question of water purification in relation to stream pollution; third, the newer developments in water softening and, fourth, the state control of semi-public water supplies.

Following the appointment of the committee for the present year, a letter was received from the chairman of the executive committee of the conference, suggesting that the thought of the water supply committee be directed especially to the second of the four developments discussed by the committee last year, namely, the relation of water purification to the pollution of raw water supplies taken from streams and other surface sources. Although the present report deals primarily with this topic, it is desired first to record certain recent happenings in the general field of water supply and purification which may be of particular interest to members of this Conference.

General Developments

In the field of state control of water supplies from a quality standpoint, a highly significant tendency during the past year has been the extension of the plan of holding annual state conferences on water supply and purification, along lines similar to that of the Ohio Conference on Water Purification, which held its fifth annual meeting in 1925. During 1925, two states, namely, Kentucky and West Virginia, held their first conferences of this kind, both of them having been organized and held under the auspices of the respective state departments of health.

According to information furnished by Mr. Waring and other members of this committee, water purification conferences of the kind above noted either have been organized permanently or have been held informally in the following states: Illinois, Kansas, Kentucky, Michigan, North Carolinia, Ohio, Oklahoma, Texas, and West Virginia. It has been understood from Mr. Foote that an informal meeting of water purification plant operators was to be held in Montana in April in connection with a section meeting of the American Water Works Association. Mr. Moses of Pennsylvania writes that Professor Walker of the Pennsylvania State College has instituted a movement for the formation of an association of water works operators in that state, with the first meeting tentatively planned for the coming summer.

Another development of general interest to state health authorities in the administrative control of the quality of water supplies has been an increasing recognition by the courts of the liability of the owners of water supply utilities, both public and private, and likewise of municipal and private corporations discharging sewage and other wastes into watercourses, for the occurrence of water-borne diseases resulting either from the excessive pollution of water supplies or from failure to maintain proper and adequate safeguards with respect to the quality of these supplies. An important decision bearing on this question was handed down in the case of Aronson vs. the City of Everett, Wash., which emphasized also the financial liability incurred through negligence in the matter of permitting cross-connections between drinking water and polluted industrial water supplies. The dangers involved in allowing such cross-connections were further emphasized during the past year by intestinal disease outbreaks reported at Winona Lake, at Niagara Falls, and at Washington, which were definitely traced to this cause.

In the above connection, Mr. Moses has brought to the committee's attention an interesting case in Pennsylvania during the past year, in which a severe outbreak of typhoid fever occurred in a small community supplied with water by a private company. A strong suspicion having existed that the epidemic was water-borne, and the water company having been apathetic in assuming its charter responsibilities, the Public Service Commission of the State instituted a complaint against the company and after a careful investigation and hearing, issued a drastic order including all the conditions deemed by the State Health Department to be necessary for the proper operation of the water works in

the future. This case is mentioned as an example of the recognition of the liability of the owners of water supply utilities to official state bodies for the proper sanitary protection of water supplies, which is becoming increasingly well established in certain states.

On the technical side, the year 1925 was marked by a number of outstanding developments, of which perhaps the most notable was the appearance of the first edition of the Manual of American Water Works Practice, published by the American Water Works Association. Another contribution of general interest was the publication by Gillespie of a census of water filtration plants in the United States. The theories underlying water purification processes, and especially of sedimentation, received further attention, as well as those bearing on the design of rapid sand filters. Rapid fine sand filtration was discussed by Blaisdell, who described a type of filter somewhat intermediate between the usual slow sand and rapid sand installations. Growing difficulties experienced in the purification of the water supplies of cities located on the Great Lakes, owing to the proximity of sewer outfalls to the water intakes and to conditions peculiar to the situation, were noted by several writers.

The subject of chloro-phenol tastes in water supplies continued to occupy a considerable amount of the attention of water works and public health officials. Toward the end of the year, a serious and long-continued outbreak of tastes, attributed to phenols, occurred in water supplies located along the upper and middle portions of the Ohio River. Steps to effect a permanent remedy for the situation along this river and its tributaries are being taken through the cooperative action of the health authorities of the four bordering states—Ohio, Pennsylvania, West Virginia and Kentucky. Incidentally, the joint action noted provides an interesting and significant example of the possibilities existing for the solution of interstate stream pollution problems in general.

Water Purification in Relation to Stream Pollution

As far as is known, the only official agency now engaged in systematic or extensive research work bearing on this question is the U. S. Public Health Service, which has undertaken, as a part of its program of basic studies of stream pollution, to determine, by combined experiment and observation, the permissible limits of bacterial pollution of raw water supplies taken from sewage-polluted streams for purification. In preliminary publications dealing with this work, its purpose, scope and method, have been stated; likewise some of the more general conclusions reached from it. During the past year, the results obtained from the study have been brought to a point such that a more definite and specific statement of the conclusions thus far reached is possible. It is proposed to state briefly these conclusions, in so far as they refer to questions of more immediate interest to members of this conference.

The survey of the efficiency of a group of seventeen municipal water filtration plants, to which reference has been made above, has indicated that the average fully equipped plant of modern design, operated efficiently under skilled supervision and treating a water similar in its general character to that of the Ohio River, should be able to produce a chlorinated filter effluent showing an average conformance to the revised Treasury Department B. coli standard when the mean B. coli index of the raw water does not exceed approximately 5,000 per 100 cubic centimeters. The limiting figure given represents an average condition, which would not hold, necessarily, on all individual days. The results of experimental studies, made over a period of 15 months at a small filtration plant constructed and operated at the Laboratory of Stream Pollution Investigations at Cincinnati, Ohio, have given a corresponding raw water maximum approximating 8,000 B. coli per 100 cubic centimeters, as expressed in terms of the index, which figure provides a very reasonably close confirmation of the one above stated.

The data obtained from the same survey have indicated that the maximum B. coli index of the raw waters observed, consistent with the production of unchlorinated effluents conforming to the revised Treasury Department standard, is equal approximately to 60 per 100 cubic centimeters. The results of the experimental studies above noted likewise have confirmed this figure with reasonable closeness, the indicated raw water maximum in this instance being 100 per 100 cubic centimeters.

The wide disparity between the indi-

cated limits of raw water pollution permitting the delivery of unchlorinated and chlorinated effluents, respectively, meeting the Treasury Department standard, affords striking evidence of the extent to which water filtration plants treating the more highly polluted water are dependent, under present conditions, on the continuous and effective use of chlorine as an aid in bacterial removal. In this connection, a question arises as to whether current tendencies in the operation of filtration plants may be too strongly in the direction of using the filtration processes properly merely for the purpose of clarifying water and of depending largely on chlorination for bacterial efficiency. This tendency would exist quite naturally as a result both of the present stress placed on economy of plant operation and of the fact that chlorination is available as an aid in accomplishing this purpose. On the other hand, it seems fairly evident that without chlorination it would be virtually impossible for existing filtration plants, without considerable further elaboration, to produce effluents having as high a degree of bacterial quality as is indicated by the revised Treasury Department standard, from raw waters containing B. coli in densities as high as 5,000 per 100 cubic centimeters. For purposes of administrative control, a more rational working standard of raw water pollution probably should fall somewhere between the two limits above stated, its magnitude depending to a large extent on the proportion of the total bacterial efficiency of chlorination which is held in reserve as a factor of safety. It should be emphasized that the limiting figures given are merely observational maxima and are not intended as working standards of permissible raw water pollution.

The studies thus far completed have indicated that the efficiency of bacterial removal, when expressed in terms of the B. coli index, is not influenced to any great extent by changes in season or by variations in raw water turbidity; hence the observational maxima above stated, when expressed in similar terms, are likewise little influenced by these two factors. When expressed in terms of the bacterial plate count, however, both factors have been shown to modify the indicated efficiency of bacterial purification. For this reason, the B. coli index, and likewise its equivalent when expressed in terms of "most probable numbers" of B. coli appears to be a more highly stabilized and, in general, more satisfactory measure of the bacterial relationships under discussion than is the ordinary plate count. This statement holds true, however, only where averages based on a considerable number of individual tests are concerned, as the error of determination inherent in the B. coli test, as currently made, is relatively high for single results or small groups of them.

In this connection, it may well be pointed out in passing that with the increasing amount of attention which is being devoted to quantitative bacterial measures of water pollution, methods currently followed in the enumeration of bacteria included under the B. coli group are becoming more critically studied than has been true in the past. The methods used in calculating the B. coli index, as ordinarily determined, have varied considerably and the index figure itself does not give even a reasonably precise measure of the probable density of this group of organisms in a given sample or series of samples of water. The time is rapidly approaching, if it has not already arrived, when a more precise and more highly standardized method of enumerating B. coli should be adopted for general use among water works sanitarians. The basis of such a procedure has been well established through the pioneer work of McCrady and the later studies of Stein, Wolman, Greenwood, Yule and Reed. It remains for the results of these studies to be codified and reduced to a practical working basis, and it is believed that this is entirely feasible with the means now at hand. It is recommended that the Conference give some thought to this subject, particularly in its relation to specifications for the quality of raw waters and effluents of purification processes, in order that appropriate action may be taken in due time to secure a properly unified procedure in matters connected with the interpretation of B. coli tests.

The studies of the Public Health Service above noted have been confined, thus far, to filtration plants of the type such as are found along the Ohio River and treating raw waters similar to that of this stream. They have been restricted in their geographical scope, moreover, to states east of Indiana and north of Kentucky. Before any generalizations based on these studies can be made, it is highly

desirable and, in fact, essential, that the past observations made along these lines be extended to include other portions of the country and other classes of raw waters than those already covered. In this connection, it would be especially desirable to secure observations on plants operated in states immediately west of the Mississippi River and in the territory bordering the Great Lakes, where water purification problems are different in many respects from those found in the Ohio River basin proper. Members of this Conference can assist greatly in pursuing these observations by suggesting sources of material and by aiding actively in securing such material for analysis.

It originally was intended to devote this report largely to a discussion of the efficiencies and permissible limits of bacterial loading of separate stages of water purification, laying particular stress on preliminary sedimentation and coagulation. On further consideration, however, it appeared inadvisable to follow the original plan, owing to the fact that no definite limit can be assigned to the bacterial densities of the several influent waters, as delivered to various stages of treatment, until a definite specification can be made as to the maximum permissible bacterial or B. coli content of unchlorinated or of chlorinated filter effluents. A specification of this kind depends, in turn, on a decision as to the extent to which chlorination is to be held as a factor of safety for filtration processes proper, a question which lies outside of the province of this committee and within that of the Committee on Chlorination of Water. As soon as the latter committee has reached a final conclusion on the point in question, a more satisfactory base line then will have been established for assigning concrete limiting values for the bacterial contents of the influent waters as delivered to successive stages of treatment.

In order that the studies of this committee may be brought to a definite set of conclusions on the main question submitted to it for the current year, it is recommended that these studies be continued in close coordination with those of the Committee on Chlorination of Water. The subject selected for special discussion in this report, though capable of being reduced ultimately to a few fairly simple and practical conclusions, is an extremely complex one from a standpoint of its analysis; moreover, it must be studied extensively and for a considerable period of time before its final results can be definitely formulated. Meanwhile, your committee has endeavored to report such progress as has been made and, further, to bring to the attention of the Conference other phases of the general subject of water supply sanitation which appear to be worthy of special comment.

SWIMMING POOL DESIGN, CONSTRUCTION AND OPERATION

(Editor's Note: Following is the full text of the Joint Committee on Bathing Places made to the Conference of State Sanitary Engineers, June, 1926. On this Joint Committee C. G. Gillespie and H. V. Pedersen represented the State Sanitary Engineers and Jack J. Hinman and Howard W. Green represented the American Public Health Association. Stephen De M. Gage, Harry F. Ferguson and E. S. Tisdale represented both organizations.)

During the past five years the Committee on Bathing Places of this Conference has been practically identical in personnel with a similar committee of the Sanitary Engineering Section of the A. P. H. A., and these two committees have worked in effect as one body with a uniform program. At the Conference in May, 1925, it was voted to make this in fact a joint committee and in October, 1925, a similar vote was passed by the A. P. H. A. Section. The present report, the sixth to this Conference, is the work of this joint committee. At the present time the committee consists of seven members, three holding appointment from both organizations, two appointed by the A. P. H. A. Sanitary Engineering Section and two appointed by the Conference of State Sanitary Engineers.

In the first report to the Conference in 1921 the committee recommended that the bathing load at swimming pools be definitely limited by the amount of clean water available and by the frequency of disinfection.

In the third report to the 1923 Conference standards were proposed for the physical, chemical, and bacterial quality of swimming pool waters, together with certain operating regulations which the committee believed necessary for the

maintenance of those standards. While these standards were not formally approved by the Conference nor by the Sanitary Engineering Section of the A. P. H. A. to which they were also presented, they have been accepted quite generally by sanitary authorities and wholly or in part have been adopted into the sanitary code of a number of states and municipalities.

In the fifth report to the 1925 Conference the committee presented a compilation of the opinions of a considerable number of swimming pool operators, physical instructors, etc., as to the number of bathers who should be permitted to use a pool at one time, the proportion of pool area which should be provided for non-swimmers, the safe depth of water for diving from various elevations, the number of bathers who may safely be permitted in the water near diving boards, with certain related information.

In response to numerous requests in this, its sixth report to the Conference, the committee has attempted to correlate various data and conclusions from previous reports with the best modern practice in swimming pool design, construction, and operation in such form that after due discussion and amendment they may be combined with the standards of the 1923 report into a Standard Code of Bathing Place Sanitation.

Classification of Bathing Places

(a) The term "Bathing Place" as used in this report includes all bodies of water sufficiently deep for complete immersion of the body and used collectively by numbers of persons for swimming or recreative bathing, together with the shores, buildings, equipment, and appurtenances pertaining to such bathing places. It does not include public or semi-public baths where the main object is the cleansing of the body or the practice of the healing art, unless such baths contain pools or tanks used collectively by a number of individuals.

(b) Bathing places may be divided into three classes. A—Natural outdoor ponds, rivers, tidal waters, etc. B—outdoor pools which are partly artificial and partly natural in character. C—Pools outdoor or indoor which are entirely of artificial construction. Natural ponds, rivers, etc., are necessarily dependent upon natural flow or upon wind and wave action for circulation of the water. Artificial and partly artificial pools may be divided into four classes according to the method by which water cleanliness is obtained. 1. Large semi-artificial pools in which the water cleanliness is maintained by natural flow or circulation. 2. Fill and draw pools where cleanliness of water is maintained by complete removal and replacement of the water at periodic intervals. 3. Flowing through pools where cleanliness is maintained by circulation of water through the pool from some natural or artificial source, but where the outflowing water is wasted. 4. Recirculation pools in which circulation of the water is maintained through the pool by pumps, the water drawn from the pool being clarified by filtration before being returned.

General Principles of Bathing-Place Sanitation

(a) In the control of swimming pool and bathing place sanitation certain broad principles apply to all classes of public bathing places.

(b) The committee is of the opinion that all public bathing places both natural and artificial should be under the sanitary control of the public health authorities.

(c) In the opinion of the committee the same standards of cleanliness and bacterial purity of the water and the same precautions against the possible spread of disease should apply at both indoor and outdoor swimming pools.

(d) The requirement should be the same for all artificial and semi-artificial pools whether located indoors or outdoors, so far as the features of design and equipment apply to maintenance of cleanliness of the pool and of the water with which it is filled.

(e) At public bathing beaches on natural waters the same sanitary standards should apply to bathing houses, dressing rooms, toilet facilities, etc., and to the handling and care of bathing suits, towels and other articles of bathing apparel as would be required at artificial swimming pools.

(f) Sanitary drinking fountains with a supply of pure water should be installed at all bathing places. The use of towels, drinking cups, combs, hair brushes, or other toilet articles for common use should be strictly prohibited.

Bathing Beaches

(a) It is desirable that the bathing water at public bathing places on natural streams, lakes, tidal waters, etc.,

should be of the same standard of bacterial quality as is required for swimming pools. It is also desirable that the same standard of cleanliness be applied although it may at times be necessary to sanction public bathing in waters which contain more turbidity and color than would be permissible in an artificial pool.

(b) In the selection of a natural bathing beach a careful study should be made of the possibility of pollution by sewage, giving due regard to natural currents, wind action, and similar factors. Attention should also be paid to the possibility of fouling of the waters and beach by algae or by aquatic plants growing on the bottom or washed in from outside.

(c) The shore and bottom at a natural beach should be of sand with no sudden slopes or holes up to a water depth of 6 ft. There should also be no swift treacherous currents or submerged rocks or other dangerous obstructions within the bathing area.

(d) In a number of instances disinfection of waters at natural bathing beaches has been carried out with considerable success. At Washington some years ago the waters of the so-called tidal basin were treated with liquid chlorine applied from a boat, and this procedure has since been used at other places. At Detroit in 1925 the waters of the river were treated with liquid chlorine from a perforated pipe laid in the bottom of the river a short distance above the public bathing beach. The results of both these methods of safeguarding bathing waters which would otherwise have been unsuitable for use were said to have been reasonably satisfactory. The amounts of chlorine to be used in treatment of natural bathing waters should be governed by the same requirements as defined in the committee standards for artificial pools.

Location and Layout of Pools

(a) The location of an outdoor pool will be governed largely by local conditions, and arrangement of dressing rooms, etc., can be made to conform to the sanitary requirements. In locating an indoor pool careful study must be given to architectural and engineering features in order that the proper layout may be obtained.

(b) The layout or arrangement of entrances and exits of the pool room in relation to dressing rooms, showers, toilets must be such as to enforce proper routing of bathers. Coming from the dressing room a bather should be required to pass the toilets, and go through the shower room before arriving at the pool entrance. Bathers should leave the pool through a separate exit leading to the toilets and dressing room.

(c) At pools used simultaneously by both sexes separate entrances and exits should be provided for men and women. There should be no connection between men's and women's quarters.

(d) Entrances and exits must be located at shallow water portion of the pool.

(e) If pool is to be of recirculation type, ample room must be provided for filters and other units. All recirculation piping inlet and outlet valves, etc., must be located where they will be readily accessible.

(f) At indoor pools where liquid chlorine disinfection is to be used, it is recommended that the chlorine apparatus be located in a glass enclosure in the pool room in order that dosage may be under the immediate supervision of the pool attendant.

Design and Construction Features

(a) Any material which will provide a tight tank with smooth and easily cleaned surfaces may be used for an artificial swimming pool.

(b) The details of design in so far as they relate to strength of materials, water-proofing, etc., are essentially the same as in design of other tanks of similar size and shape and are, therefore, omitted from this report.

(c) *Shape.* Indoor pools should be of rectangular shape with deep water at or near one end and shallow water at the other. Small outdoor pools should be of same general design as indoor pools. The best shape for large outdoor pools depends largely on the size and on local conditions. It is considered better practice to build large pools with the deep water area in the center.

(d) *Dimensions.* For swimming records a straightaway course of at least 60 ft. with 5 ft. lanes is required. Length of pool should be not less than 60 ft. and width should be some multiple of 5 ft. The area to be provided for the expected bathing load is discussed in a subsequent paragraph.

(e) *Depth of Water.* The minimum depth of water in the deep portion of any public pool should be not less than 6 ft.

(f) *Proportion of Deep and Shallow Water.* Some authorities recommend that the area of shallow water, 5 ft. or

less in depth, should be 80% or more of the total area of large outdoor pools. Such proportioning must be considered in relation to the pool volume the bathing load, the recirculation or flowing through purification system, etc. The committee has insufficient information on this point to warrant any recommendation at the present time.

(g) *Slope of Bottom.* The slope of the bottom of any part of a pool where the water is less than 6 ft. deep must not be more than 1 ft. in each 15 ft. There should be no sudden change of slope within the area where water depth is less than 6 ft.

(h) *Side Walls.* The side and end walls of all artificial and semi-artificial pools should be vertical. Sloping side walls are dangerous and cannot easily be kept clean.

(i) *Pool Lining,* including bottom and sides up to runways must be of white or light color material and present a smooth finished surface without cracks or joints. All corners must be rounded. Tile or glazed brick lining is recommended for all indoor pools and for small outdoor pools. White cement smoothly finished is satisfactory for large outdoor pools. Dirt does not show on asphalt or other similar dark material and such materials are not suitable for pool lining. The use of paint or similar material to obtain a light colored finish is not satisfactory and should not be permitted. Sand or earth bottoms cannot be kept clean and are not recommended for pools.

(j) *Markings.* It is recommended that swimming lanes be marked on the bottom with dark colored material of the same kind as the pool lining. The outlet of the pool should also be plainly marked by a black or dark colored circle, unless outlet grating is of conspicuous coloring. The depth of water at deepest point and at the 5 ft. point should be conspicuously marked on both sides of a pool with deep water at one end. Markings showing depths in 1 ft. increments are desirable. In large pools with deep water only in the middle the 3 and 5 ft. depth line should be conspicuously marked on the bottom and also designated by surface floats.

Proportioning Pool Area to Expected Load

(a) In the design of an artificial pool due allowance must be made for the number of bathers who may be expected at the time of maximum use. In computing the area which must be provided it is recommended that the pool be divided into three zones, and the area of each computed separately.

(b) From the data collected by the committee for its fifth report, it was the consensus of opinion that an area extending 10 ft. from the extremity of a diving board or tower should be considered as reserved for divers, and that not more than two or three persons should be permitted in the water in this area at one time while diving is in progress. About three times that number will be on the shore or diving platform awaiting their turn to dive. Twelve persons is, therefore, the maximum number which may be permitted for the area within 10 ft. radius of each diving board or platform.

(c) It was the consensus of opinion of swimming pool operators that the space required by a swimmer might fairly be expressed as five-fourths the square of his height and that on an average two-thirds of the swimmers present would be in the pool at the same time. On this basis the average space requirement for an adult swimmer is 36 sq. ft. and allowing for one-third of swimmers on the shore, an area of 27 sq. ft. should be provided for each swimmer who may be expected to be present at time of maximum load.

(d) In computing the area to be provided for persons who do not swim we must take into consideration the character of the pool. At indoor pools and small outdoor pools this area should probably be included with the swimming area and the crowding limit computed as such. At large outdoor pools where a considerable proportion of the water is shallow water, we may assume that 50% of the non-swimmers would be on shore. The average space allowance for each non-swimmer in the water is approximately one-half that of the swimmer in deep water. Combining these factors an allowance of 10 sq. ft. per bather should be allowed for this portion of the pool.

Inlets and Outlets

The following specifications apply for all flowing through and recirculation pools.

(a) All pools should be provided with an outlet at the deepest point of sufficient size to permit the pool to be completely drained in four hours or less. Outlet opening in the floor of the pool should be at least four times the area of the discharge pipe to reduce suction cur-

rents. This opening must be covered with a proper grating.

(b) In rectangular pools with deep water at or near one end, multiple outlets should be provided where the width of the pool is more than 20 ft. In such cases outlets should be spaced not more than 20 ft. apart, nor more than 10 ft. from side walls.

(c) Proper pipe connections must be provided in recirculation pools to permit water being drained directly to the sewer, as well as to recirculation pumps. In making connections of pool outlets with sewers proper care must be taken to prevent any possibility of sewage from the building or from outside backing up into the pool.

(d) Inlets for fresh or re-purified water should be located to produce as far as possible a uniform circulation of water throughout the entire pool. In semi-artificial pools of irregular shape a careful study should be made of probable circulation currents and inlets located and spaced to provide as complete circulation as possible. All inlets should be located at the shallow water portion of the pool and not more than 1 ft. below water line, except in cases where reverse circulation is used as discussed in paragraph (h).

(e) Where the distance across the shallow portion of the pool is more than 20 ft., multiple inlets must be provided so spaced that each inlet will serve a linear distance of not more than 20 ft. At spoon shaped rectangular pools where the outlets are located more than 5 ft. from the end wall, inlets should be placed at both ends of the pool. At large pools with outlets near the center, inlets should be placed at the specified intervals entirely around the perimeter of the pool.

(f) In small rectanglar pools with only a single inlet and a single outlet, inlet and outlet should be located on a line drawn lengthwise through the center of the pool. Inlet orifices located at or below normal water level should be covered with a grating having openings of at least twice the orifice area.

(g) Each inlet should be designed as an orifice and proportioned to supply the volume of water required at that particular point to obtain the best circulation. Inlet piping should be designed to provide at least twice the area of the inlet orifice. In large pools the inlet pipe system should be designed in sections with gates to permit regulation of the flow to different inlet orifices.

(h) In a few cases pools have been designed for fresh water or re-purified water to enter at the deep point and overflow through outlets or scum gutters in the shallow portion. It is believed there may be some advantage in having flow through the pool in this direction, thus permitting floating matters and dirtier waters from the more crowded shallow area to be carried off more rapidly. The committee suggests that in designing piping systems for recirculation or flowing through pools, cross connections be provided so that flow through the pool may be in the direction which experiments may prove most desirable. It is also suggested that the question of having scum gutters serve as overflows and outlets in recirculation or flowing through systems be studied more carefully, as it appears that such design may have certain material advantage.

Scum Gutters

(a) Scum gutters should extend completely around the pool. Design of scum gutters should be such that matters entering them will not be washed out by a sudden surge of entering water, and that danger of bathers catching arms or feet in them be reduced to a minimum. The edge of a scum gutter should be designed to serve as a hand hold for bathers. Gutters should, therefore, be sufficiently deep that bathers' fingers will not reach to the bottom. Sufficient opening must be provided to permit mechanical cleaning of the gutters.

(b) Drainage outlets should be provided at least every 10 ft. Outlets and outlet pipes should be of generous size to permit rapid carrying away of water during surface flushing or reversed flow. Drainage from scum gutters may be conducted direct to sewers or to suction of recirculating pumps. Both such connections are advised.

(c) All scum gutters should be recessed into the pool wall. There is no legitimate objection to having scum gutters project slightly into the pool to permit drainage from runways to flow directly over the edge of the pool into them. Such projection should not, however, be more than 2 in.

Steps, Ladders, Etc.

(a) Steps or stairways for entering and leaving the pool should be of such construction as to minimize danger of accidents. Ladders or stairways should be located at one or both sides of the

deep end of the pool. If distance from bottom of pool to runway is more than 2 ft., a ladder or steps should also be placed at shallow end of the pool. Treads of ladders or steps should be of non-slip material.

(b) In some pools ladders have been replaced by step holes inserted in the pool wall. If step holes are provided, they should be of such design that they may be readily cleaned and be provided with drains into the pool to prevent accumulation of dirt.

(c) Stairs, ladders, or step holes should have a hand rail on both sides at the top leading out over the runway. Stairs should not project into the pool. If stairs are desired, the stairway should be recessed into the wall and the runway of the pool.

Runways or Sidewalks

(a) Runways not less than 4 ft. wide should extend entirely around the pool. Runway floors should have a slope of about one-fourth inch to the foot, should be smooth and easily cleaned but should be as far as possible of non-slip construction at the edge of the pool runway must be of non-slip construction for a width of at least 1 ft. The edge of the pool at its junction with the runways should be rounded. At indoor pools, unless runways are very wide, handrails on the outside wall are desirable.

(b) The older practice was to require runways of all pools to slope away from the pool with drainage vents at intervals connecting with the sewer. Such a requirement seems unnecessary for indoor pools. The water carried out on runway is of the same character as that in the pool. Modern trend of opinion is toward having runways of indoor pools slope toward the pool with drainage into scum gutter or scum gutter drainage system. At outdoor pools so located that much dirt is blown in from outside it is desirable to have the runways slope away from pool to permit flushing such dirt directly to the sewers.

(c) Some sanitary authorities also require a raised edge 2 in. or more in height between the pool and runways. Such raised edge may lead to accidents by bathers tripping thereon and cannot be recommended for indoor pools. At outdoor pools a raised edge forms a barrier between pool and runway and permits the use of greater hose pressure for flushing. If installed for this purpose, such an edge should not be less than 1 ft. wide and at least 6 in. high in order that danger of accidental tripping may be reduced as much as possible.

(d) High, tight walls should encircle the pool outside the runways. Some outdoor pools have been constructed with areas of sand or grass and shrubbery just outside the runways. This practice is objectionable as it leads to tracking of much dirt into the pool. Trees and shrubbery overhanging or adjacent to the pool or runways are also objectionable and may cause much unnecessary dirt in the pool.

Visitors' Galleries

There must be an absolute separation of the space used by spectators and that used by bathers. There should be no means by which bathers can enter space reserved for spectators or vice versa. Visitors' quarters must have a separate entrance. Galleries for spectators should not overhang any portion of the pool surface. Floor and foot rail of the gallery should be of tight construction to prevent dirt tracked in from getting into the pool. Gallery floor should slope to a drain and should be flushed down with hose regularly. Seats in galleries should be of non-absorbent construction to permit washing.

Dressing Rooms

(a) Bath houses to be used simultaneously by both men and women should have two parts, one for each sex, entirely separated by tight partitions.

(b) Floors of all dressing rooms, locker rooms, etc., should be of smooth finished material, impervious to moisture, with no open cracks or joints. All floors should have a pitch of about one-fourth inch to the foot and should slope to a proper drain to permit washing down with a hose. All junctions of floor with side walls and partitions should be finished with rounded joints.

(c) Walls and partitions of all dressing rooms, locker rooms, etc., should be of smooth, impervious material, without open cracks or joints. If walls of wood or similar material are used, all cracks and joints should be filled and the surface kept finished with paint or other sanitary water proof coating. Partitions between dressing compartments should terminate not less than 4 in. above the floor to permit flushing of entire floor area.

(d) All furniture used in dressing rooms should be of simple character and of easily washable material. Lockers where provided should be of vermin

proof construction with tight joints. All lockers should be properly ventilated.

(c) All dressing rooms and appurtenances must be kept clean at all times. The use of a vermifuge spray for lockers and of a disinfectant on floors, walls, seats, etc., at frequent intervals is recommended. Foot tubs in dressing rooms at beach houses should be prohibited..

Showers, Toilets, Lavatories

(a) Adequate shower bath facilities with hot and cold water must be provided at all artificial pools. The minimum number of showers provided should be in the proportion of one for each 40 bathers expected at time of maximum load. At pools where mixed bathing is permitted it can usually be assumed that two-thirds of bathers at time of maximum load will be men.

(b) Shower baths should be of such design that a proper mixture of hot and cold water may be obtained without danger of scalding the bather.

(c) A foot trough with running water is desirable at entrance to outdoor pools and to beach bath houses. At certain pools operated in conjunction with surf bathing, it has been found advisable to make a wading pool of the entrance passage with automatic or continuous flow showers overhead, through which all bathers must pass on return to the pool.

(d) At public bathing beaches a sufficient number of showers should be provided to permit all bathers to rinse off sand and dirt before entering the dressing rooms.

(e) Adequate and proper toilet facilities must be provided at all pools and beach bath houses. The minimum number should be one toilet for each 40 women and one toilet and one urinal for each 60 men.

(f) Water flush toilets should be used wherever possible. Chemical closets may be used if proper sewage disposal is lacking. All closets and urinals must be properly serviced. Privies of any type are not recommended for public bathing places.

(g) Lavatories located adjacent to toilets should be provided at all swimming pools in the proportion of one bowl to each 60 persons using the pool at time of maximum load.

Lighting, Ventilation, Heating

(a) A complete system of artificial lighting must be provided for all pools, bathing beaches, bath houses, dressing rooms, etc., which are to be used at night.

(b) Lighting fixtures must be of such number and design as to light all parts of the swimming pool and the water therein.

(c) Arrangement and design of lights must be such that life guards may see clearly every part of the bathing waters at a beach or pool and all spring boards, towers, floats, and other bathing appurtenances, without being blinded by the light.

(d) Indoor pools should be so located that they may be lighted during the day by windows on at least one side or by skylight. The window or skylight area should not be less than one-half the area of the pool including the runways.

(e) All indoor pools and all bath houses, dressing rooms, shower rooms, toilets, etc., at both indoor and outdoor pools and beaches must be properly ventilated. Ventilation of indoor pool rooms must be so designed that direct draft will not blow on bathers.

(f) At all indoor pools except those so located that outside temperature never falls below 60° F. the pool room and all dressing rooms, shower rooms and toilets should be artificially heated to a temperature of between 70° F. and 75° F. Thermostatic control of the temperature of the air in the pool room and of the water in the pool is desirable.

Recirculation System

(a) The recirculation system consists of the pumps, hair-catcher, and filters together with all necessary pipe, connections to the inlets and outlets of the pool. The water heater, the chlorinator and the suction cleaner are also usually installed on or connected with the recirculation system and may be considered as integral parts thereof. This entire system and all its component parts should be designed to provide the required volume of recirculation water as specified with a minimum of frictional resistance. Filtration and disinfection are discussed separately in subsequent paragraphs. The requirements for other parts of this system are as follows:

(b) *Pumps.* Centrifugal pumps are preferable for swimming pool circulation, although plunger pumps are sometimes used. Electric drive is also preferable. When pipe lines from suction cleaner lead to pump suction, a pump which will develop good vacuum must be used. When pressure filters are used pumps must be designed to pass the re-

quired volume under the maximum head which may develop in the filters. When designed to operate with multiple unit filters it is advisable to have pumps in duplicate with proper cross connections to permit one filter to be washed with the effluent from another. If filters are located at an elevation higher than the water line of the pool a check valve must be placed on the pump suction.

(c) *Hair Catcher.* The recirculation system should include a strainer to prevent hair, lint, etc., from reaching the filters. The best type of hair catcher consists of a metal chamber containing a removable cylindrical strainer, so arranged that the water passes through the strainer from the outside. The strainer should be of non-corrosive material with openings not more than 1/32 in. across. A slotted strainer is more easily cleaned than one which is perforated. The area of strainer openings should be at least ten times the area of the water inlets. Hair traps should be so constructed that they can be quickly taken down for cleaning by loosening two or three wing-nuts. Proper valves should be provided to prevent flow of water through strainer while cleaning.

(d) *Water Heater.* In northern climates some method of heating the water is essential for indoor pools. Blowing steam directly into the pool as is practiced in some instances or heating coils placed directly in the pool are not recommended. A heater designed to heat all or a part of the circulation water is preferable. In designing a heater ample surface for heat interchange must be provided. Such a heater may be designed for use with steam or hot water. Automatic thermal control is desirable. Provision should be made for easy removal of the heater part for cleaning.

(e) *Suction Cleaner.* In the opinion of the committee the only satisfactory method of removing the dirt, hair, etc., settling on the bottom of a pool is by means of a suction cleaner. As such cleaners are commonly operated by the circulation pumps, they may be classed as an adjunct to the recirculation system. When a suction cleaner is to be operated by the recirculation pump a gate with graduated stem or other registering device should be provided for throttling flow from pool outlet to permit pump to operate at maximum efficiency when suction cleaner is in use. Fixed pipe connections for attachment of suction cleaner to pump suction should be of ample size to reduce friction to a minimum and the cleaner and all removable connections be designed to provide a maximum velocity at the suction nozzle.

(f) *Piping System.* The piping system should be properly designed to reduce friction losses to a minimum. Pipe capacities should generally be at least double the theoretical value. Flange joints or unions should be inserted at intervals to permit any part of system to be quickly taken down for cleaning or repairs. A sump and blow off should be provided at the lowest part of the system to permit removal of any accumulating iron rust. Openings should be provided for insertion of gauges to permit vacuum on pump suction and pressure at discharge to be determined, should a study of the recirculation system be desirable. It is advisable also to make provision for insertion of Pitot tubes or meters for checking actual volume of water passing through the system under working conditions. Outlets should be provided for obtaining samples of the water as it leaves the pool and after filtration for purposes of laboratory tests. Other requirements for piping are discussed under the heading "Inlets and Outlets."

(g) *Testing the System.* After the recirculation system has been installed and the various units tuned up, a test of the hydraulic properties of the entire system and of each integral unit should be made. In such a test the velocity in the piping system at various points, the discharge capacity of each filter and each pump, the velocity and volume of wash water in each filter, and the rate of discharge at each pool inlet should be determined under actual working conditions with the pool at normal working level. The full data of this test should be a matter of permanent record for future comparison. A similar test repeated at least once a year is desirable.

Proportioning the Water Interchange for Recirculation and Flowing Through Pools

(a) In a recirculation or flowing through pool in which the dirty or used water is continually being withdrawn and replaced by fresh or filtered water, purification of the pool water proceeds by consecutive dilution. The first portion withdrawn from the pool will all be dirty water but, owing to the constant admixture of entering clean water with the dirty water remaining in the pool, each succeeding portion of water withdrawn will consist of a decreasing pro-

portion of dirty water mixed with an increasing proportion of clean water. In proportioning the rate at which fresh water should be added to a flowing through pool, or the capacity of pumps, filters, etc., for a recirculation pool, this law must be taken into consideration.

(b) Gage and Bidwell have recently worked out the law of purification by consecutive dilution as applied to recirculation and flowing through pools. The following abstract of a paper in preparation has been prepared by the authors for this report.

(c) It is proposed that the rate of water interchange in a recirculation or flowing through pool be expressed as the ratio of the volume of clean water entering the pool in 24 hours to the total pool volume. For convenience this ratio may be called the "Turnover" rate or "T" of the pool purification system. For example T=1 when the volume of water recirculated in 24 hours is the same as the pool volume, T=2 when the water circulated in 24 hours is twice the pool volume, etc.

(d) It can readily be demonstrated by computation and by experiment that 7 turnovers are required to effect a removal of 99.9% of the dirt present in the water of the pool when recirculation was started. At the end of the first turnover the purification will be about 63%, after two turnovers about 86%, at the end of three turnovers about 95%, after four turnovers about 98%, after five turnovers 99.3%, and after 6 turnovers 99.7%. To accomplish a purification of 99.99% 10 turnovers will be required.

(c) If the pool is used reguarly by bathers further increments of dirt will be introduced into the water daily, and the removal of each successive daily increment will proceed according to the law. The result of the addition of such daily increments will be an increasing accumulation of dirt in the water up to a certain point after which the dirt content of the pool water will remain practically constant subject only to the fluctuations caused by the variations in the daily bathing load. The amount of this accumulation and the time required for the pool water to reach a condition of equilibrium depends upon the rate of turnover of the pool by the flowing through or by the recirculation system, and in the latter system is also dependent upon the efficiency of the filters.

(f) Assuming a daily increment of dirt equal to that in the pool at the start and a filter efficiency of 100%, with a daily turnover (T=1) equilibrium will be reached at the end of the ninth day when the accumulated dirt in the pool will be equivalent to about 58% of the amount present when recirculation and daily bathing was started. With two turnovers per day (T=2) equilibrium will be obtained in four days with a dirt load of about 16%, with T=3 a balanced load of about 5% will be obtained on the third day and with T=4 a balanced load of about 2% will be obtained at the end of the second day. On the other hand if the recirculation system is so small that two days is required for each turnover, accumulation of dirt in the pool will continue for about 19 days and the dirt load carried in the pool thereafter will be about 155% of the amount present at the start.

(g) It is evident, therefore, that if clean water is to be maintained, the recirculation or flowing through system must be designed to provide a turnover ratio of at least two and that where heavy bathing loads are anticipated, the turnover ratio should be three or more. It is also evident that the recirculation or flowing through system should be kept in operation continuously and that the filters should be operated in the most efficient manner. If the filters have an efficiency of only 50%, or the recirculation system is operated only half the time, the effect will be the same as though the recirculation system were only half the size.

Filtration

(a) Slow sand filters, rapid gravity filters and pressure filters have all been used in swimming pool re-purification systems. More than 80% of the recirculation pools in this country are equipped with pressure filters and for indoor pools and small pools where space is limited, this type of filter is to be preferred unless the water is very hard. For large outdoor pools the gravity type rapid filter is suitable and is preferred by some sanitary authorities. Where the water is very hard and cementation of the filter medium is likely to occur the open type of filter is to be preferred. Because of the large amount of space required, and the increased amount of hand labor in cleaning, slow sand filters are seldom used for swimming pools.

(b) Batteries of two or more filters arranged in parallel are preferable to a single unit, in order to permit continuation of filtration and recirculation while

one unit is out of operation for cleaning or repairs.

(c) Filtering material should consist of at least 36 ins. in depth of suitable grades screened sharp filter sand or crushed quartz and filter gravel. There should be at least 18 ins. of freeboard above the surface of the filter material to the overflow troughs or pipes of rapid filters to permit proper washing without loss of filter sand. In some cases filters of bone charcoal, wood charcoal or similar material have been installed on swimming pool recirculation systems. When new these materials may have considerable absorbative effect, but after a few weeks use this power is lost and the filter becomes practically worthless until the filter medium is renewed.

(d) In designing a filer system for a swimming pool the ratio of slow sand filters should not exceed three million gallons per acre per day, and the rate of rapid filters should not exceed 3 gals. per minute per square foot of surface area. Automatic rate controllers are essential on slow sand filters. Rate controllers are not usually installed on the rapid filters used for small swimming pools because of the considerable increase in cost. Filters for large pools, (100,000 gals. or more), should be equipped with rate controllers and such control is desirable on smaller installations.

(e) Rapid filters of open gravity type must be equipped with loss of head gauges. Pressure filters must be equipped with pressure gauges on the inlet pipe and the outlet pipe for determination of loss of head or back pressure in the filter medium. Pressure filters should have a proper sight glass installed on the waste discharge pipe by which the operator may watch the progress of filter washing. Such glass should be readily removable for cleaning. When pressure filters are located at an elevation above the water line of the pool each filter must be equipped with an automatic air relief valve. The arrangement and number of valves and interconnecting piping, or "valve nest", for necessary and convenient operation of rapid filters is fairly well standardized, and a discussion thereof may be omitted.

(f) Readily removable heads or a large manhole should be provided on pressure filters to facilitate inspection and repairs. Sufficient head room and working space must be allowed about filter units of all types to permit sand replacement and other repairs when necessary.

(g) If the water supply contains iron, manganese, turbidity, or any appreciable amount of color, treatment with alum or other coagulant will be necessary with slow sand filters as well as with filters of the rapid flow type. On filters for pools of more than 50,000 gals. capacity, solution tanks and orifice boxes are to be preferred to the "Alum Pot", so-called which is usually installed for use with small filters.

(h) When the water supply for a pool contains large quantities of calcium bicarbonates, and especially when such water must be heated for use, difficulty is often experienced in maintaining clear water in the pool by the usual methods of coagulation and filtration. To a certain extent this difficulty may be overcome by passing the alum treated water through a properly designed coagulation and sedimentation basis before filtration. Where the installation of a proper coagulation basin is impracticable it is suggested that water softening apparatus of the zeolite or base exchange type be installed as an adjunct to the recirculation system to permit the calcium content of the pool water to be reduced to a reasonable amount.

Disinfection

(a) From all available information the addition of liquid chlorine by use of proper apparatus is today the most satisfactory method of pool disinfection. It is possible not only to completely disinfect the entire body of water in the pool with chlorine, but also maintain in the pool water at all times a residual amount of disinfectant to immediately sterilize any dangerous pollution disseminated by bathers. With liquid chlorine apparatus it is also possible to increase or diminish the dosage as required to compensate for variations in the bathing load. The committee recommends the use of liquid chlorine for disinfection of all pools where there is any appreciable bathing load or where bathing suits are worn.

(b) A possible objection to the use of liquid chlorine for indoor pools is the chance of accidental escape of gas into the room. A modern chlorine apparatus is carefully designed and built to prevent all possibility of such accidents. As a factor of safety it is advisable to install the chlorinator and tanks in a special closet with vents near the floor connecting with a chimney or other duct leading outside the building.

(c) Next to liquid chlorine treatment continuous application of solutions of hypochlorite of lime or hypochlorite of soda is the most effective method of swimming pool disinfection. It is sometimes difficult to handle and apply these chemicals without escape of some objectionable odor into the room. When open to the air these chemicals also change rapidly in chlorine content and frequent tests of the strength of solution being applied and readjustments of the rate of application, as well as frequent tests of the residual chlorine in the pool water must be made when this method of disinfection is used.

(d) Intermittent disinfection with hypochlorites as practiced at many pools must be considered as a makeshift. It is possible to obtain satisfactory disinfection by intermittent application of these chemicals and to maintain a satisfactory residual chlorine content in the water when the bathing load is constant and not too high. When the bathing load flutcuates widely the residual chlorine content cannot be adjusted to compensate for these variations and under excess loads immediate disinfection of infectious matters from bathers may not be accomplished.

(e) Sterilization of clear water may be obtained by exposure in thin films to ultra violet rays. This sterilizing action is confined entirely to the period of such exposure and no residual disinfecting action is carried over into the pool. Disinfection, therefore, proceeds according to the law of purification by consecutive dilution and is subject to the limitations imposed by that law. There is never any disinfectant in the pool water to act on infectious material which may be discharged by bathers during the bathing period at the time when such material is most dangerous. In a few cases satisfactory control of the bacterial content of pool water has been reported by the use ultra violet disinfection alone. In a considerable number of instances, however, it has been found necessary to reinforce or supplement the ultra violet treatment by treatment with chlorine or hypochlorites. On the basis of any available evidence the committee cannot recommend the use of ultra violet ray apparatus alone for disinfection of any pool where the bathing load is high or where large temporary loads are likely to occur.

(f) Judging from a few reports a reasonably satisfactory disinfection of water may be accomplished by ozone when the necessary apparatus is properly installed and operated. The data on the use of ozone for swimming pool disinfection are very few and inconclusive. There is no evidence that ozone has any residual sterilizing effect after the water has been treated, and disinfection must, therefore, proceed according to the law of consecutive dilution and be subject to all limitations imposed by that law. On the basis of any available evidence, the committee cannot recommend this method for swimming pool disinfection.

(g) The committee recommends the use of copper sulphate in combination with either of the approved methods of disinfection at such times and in such amounts as may be necessary to control growth of algae in swimming pools and other bathing waters. The use of copper salts alone as a disinfectant will not produce satisfactory bacterial control and cannot be recommended.

Diving Towers, Spring Boards, Etc.

(a) Diving towers, when provided, shall be rigidly constructed and properly anchored to the bottom with sufficient bracing to insure stability under the heaviest possible load.

(b) Fixed platforms and floats in the water shall be constructed with an air space of at least 1 ft. beneath. There must be as little under water construction in such platforms as is consistent with strength and all braces, struts, etc., shall be designed to prevent entanglement or trapping of bathers beneath the platform.

(c) At least 12 ft. free and unobstructed head room must be provided above diving boards and towers.

(d) No diving board or platform more than 10 ft. above the water level should be permitted at any public place. The elevation of diving boards, or towers should not exceed the safe limit for the average swimmer. The concensus of opinion of swimming instructors, etc., as summarized in the Fifth Report of this committee apparently establishes the following as the minimum safe depth of water for diving from various elevations.

Elevation of Diving Platform	Minimum Safe Depth of Water
1 ft.	5 ft.
3 ft.	6 ft.
5 ft.	7 ft.
7 ft.	8 ft.
10 ft.	9 ft.

Emergency Equipment

(a) Pole hooks, ropes, buoys, and other necessary life saving equipment must be provided and be readily accessible at all pools and bathing beaches.

(b) A first-aid kit containing aromatic ammonia, tincture of iodine, sterile gauze, aborbent cotton, surgeons' plaster, and bandages of various widths should be provided for emergency use at all public bathing places.

Suits, Towels, Etc.

(a) At indoor pools used exclusively by men nude bathing should be required. At indoor pools used exclusively by women bathing suits should be of the simplest type. Suits when used should be of wool or cotton of simple design and of undyed material or tested for fastness of color. Elaborate suits of varied colors should not be permitted.

(b) At artificial pools all bathers of both sexes should be required to wear rubber bathing caps.

(c) It is desirable at artificial pools that all suits and towels be supplied and cared for by the management. If individually owned suits are permitted, they should be of prescribed style and material and should be laundered and stored at the pool by the management.

(d) All suits and towels must be washed with soap and boiling water, rinsed, and thoroughly dried each time they are used.

(e) Unless suits and towels are sent to a public laundry, the installation and use of modern laundry equipment at all public bath houses and pools should be required. Cold water washing and air drying should be prohibited. The use of a disinfectant on suits and towels in place of proper laundry methods is a makeshift which should not be permitted.

(f) A sufficient number of suits and towels should be provided to take care of the maximum number of bathers. Unless thoroughly dried by artificial heat in a modern laundry drier, suits and towels should not be re-issued on the same day that they have been used.

(g) Clean suits and towels must be kept strictly separated from those which have been used and unlaundered. Clean suits and towels must not be stored on shelves, handled in baskets or passed out over counters with which dirty suits have been in contact.

CROSS CONNECTIONS BETWEEN PUBLIC AND OTHER WATER SUPPLIES

(Editor's Note: Following is the report of the Committee on Cross Connections to the Conference of the State Sanitary Engineers, June, 1926. The personnel of the committee is: H. F. Ferguson, I. W. Mendelsohn, W. J. Scott, E. J. Tully and C. M. Baker, chairman.)

Resolutions Recommended

The Fire Protection Division of the American Water Works Association adopted the following resolutions at its convention at Louisville, Ky., in May, 1925:

"Whereas, cross connections between potable public water supplies and supplies from other sources have been the cause of a large number of outbreaks of typhoid fever and other water-borne diseases, and

"Whereas, check valves and other similar protective devices can not always be depended upon, be it

"Resolved, that no physical connection should be permitted between a potable public water supply and any other supply except as follows:

"1. With another potable public supply,

"2. With a potable supply which is regularly examined as to its quality by those in charge of the potable public supply to which the connection is made.

"This prohibition to apply to all piping systems either inside or outside of any building or buildings, and

"Be it further resolved, that definite programs should be inaugurated in each municipality to eliminate permanently all other connections."

Your committee believes that a similar resolution should be adopted by this conference changing the words, however, also to include auxiliary intakes and by-passes. The following resolution is recommended for adoption:

Whereas, cross connections, auxiliary intakes and by-passes between potable public water supplies and supplies from other sources have been the cause of a large number of outbreaks of typhoid fever or other water-borne disease, and

Whereas, check valves and other protective devices, or notifying the public in the case of using water from a polluted source through an auxiliary intake or by diverting the flow around an inte-

gral part of a purification plant through a by-pass, can not be depended upon to adequately protect the public from disease,

Be it resolved, that no physical connections should be permitted between any potable public water supplies either through cross connections, auxiliary intakes or by-passes and other supplies except as follows:

1. With another potable public water supply.

2. With a potable supply which is regularly examined as to its quality by those in charge of the potable public supply to which the connection is made.

This prohibition to apply to all piping systems, either inside or outside of any building or buildings, and be it

Further resolved, that definite programs should be inaugurated in each state and each municipality thereof permanently to eliminate all other connections, and be it

Further resolved, that the Executive Committee of this Conference transmit copies of this resolution to the Fire Underwriters' Association and related organizations, also the American Water Works Association and other analagous organizations with the request that they cooperate in securing the carrying out of the provisions of this resolution.

A report upon cross connections by a similar committee at the meeting of the Conference in June, 1921, recommending elimination of such connections was formally adopted. In view of this report and the abundance of other data relating to the subject, your present committee believes that only a brief concise final report is desirable at this time. This report, however, covers briefly the following subjects:

(1) Resolution recommended for adoption by the Conference.

(2) Definitions: Cross connections, auxiliary intakes, by-passes.

(3) Outbreaks of disease traceable to such connections.

(4) Liability of owners where disease is caused by use of polluted water.

(5) Program for elimination of cross connections, auxiliary intakes and by-passes.

Definitions

Cross Connections—A cross connection is any physical connection whereby a potable water supply system is connected with another water supply system, whether public or private, in such a manner that a flow of water into the potable supply is possible therefrom, directly through the manipulation of gate valves, because of ineffective check or back pressure valves or otherwise.

Examples of cross connections include connection between the piping systems of two supplies containing either check valves or gate valves, or both, such as are frequently used in industries to provide auxiliary supplies for fire protection or industrial purposes. It is not intended that a cross connection will include those permitting water from a public supply to discharge into an elevated tank, cistern or suction well, at an elevation above its high water-line or with a tank wholly supplied from the public supply and properly protected against contamination.

Auxiliary Intake—An auxiliary intake is any piping connection or device whereby water may be secured from a source other than that normally used.

Such connections include an auxiliary intake into a river or lake where water for domestic purposes is normally secured from another source; also conditions wherein water may be pumped from another source either by the owner of the supply or other agencies into the regular distribution system.

By-Passes—A by-pass is any system of piping or arrangement whereby the water may be diverted around any part or portion of a water purification plant.

Such connections include arrangements whereby the coagulating basin, filters or sterilization equipment of a water purification plant may be bypassed.

Outbreak of Disease

The committee submitted a tabulation of recorded outbreaks of typhoid fever and in some instances of a dysentery that have been caused by cross connections, auxiliary intakes and by-passes. This tabulation includes a total of 8,028 cases of typhoid fever with 226 deaths; also more than 11,000 cases of dysentery. Other outbreaks have, undoubtedly, occurred that have not been definitely recorded or that have not been found in the search of references by the committee. In any event the sickness and deaths are somewhat appalling and sufficient to cause any group of officials to give careful consideration to necessary steps to eliminate such dangers. The tabulation and data were presented primarily as reference for members of the Conference

in presenting this question to secure the elimination of these dangerous devices.

Liability

Courts have held on numerous occasions that the owner of a water supply, whether a municipal or a private concern, is liable for damages caused by sickness resulting from the use of a polluted water furnished by him. Below is recorded a synopsis of some such decisions:

Groen v. Ashland Water Co. (1898) 101 Wis. 258: "If defendant knew, or from the situation ought to have known, the water it is distributing was dangerous for domestic use, from some cause not discoverable ordinarily by the exercise of reasonable care, it owed the duty to its customers of disclosing that danger, and a failure so to do, knowing that such customers were liable to use the water through ignorance of its character, was a fraud in law, rendering the defendant liable to legal damages to any person injured by such fraud without fault on his part, and it was also a failure of duty amounting to actionable negligence as well, to which the same liability is incident." Five thousand dollars verdict involved.

Lockwood v. Dover (1905) 73 N. H. 209: Negligence was alleged in that defendant municipal corporation failed to clean out its water pipes or to provide means whereby they could be cleaned out, and that in consequences thereof foreign and decayed matter became lodged in the city's pipes, entered the pipes leading to the plaintiff's dwelling and was there drunk by the plaintiff's intestate, causing him to sicken and die. It was held that the defendant was liable.

East Grand Forks v. Luck (1906) 97 Minn. 373: Based upon a study of the following cases Roed v. City of Anoka, 85 Minn. 294, 88 N. W. 981; Walla Walla City v. Walla Walla Water Co., 172 U. S. 1, 19 Sup. Ct. 77, 43 L. Ed. 341; Illinois Trust & Savings Bank Co. v. Arkansas, 76 Fed. 271, 22 C. C. A. 171, 34 L. R. A. 518, Judge Elliott said: "When the municipality enters the field of ordinary private business, it does not exercise governmental powers. Its purpose is not to govern the inhabitants, but to make for them and itself private benefit. As far as the nature of the powers exercised is concerned, it is immaterial whether the city owns the plant and sells the water, or contracts with a private corporation to supply the water. It is not in either case, exercising a municipal function. . . . When a municipality engages in a private enterprise for profit, it should have the same rights and be subject to the same liabilities as private corporations or individuals."

Keever v. Mankato (1910) 113 Minn. 55: "When a municipality voluntarily engages in selling and distributing water to customers for its local advantage or profit, it enters the field of ordinary private business, and has the same rights and is subject to the same liabilities as private corporations or individuals with respect to damages from impurity of the water. . . . It is obvious that a sound public policy holds a city to a high degree of faithfulness in providing an adequate supply of pure water. Nor does it appear why the citizens should be deprived of the stimulating effects of the fear of liability on the energy and care of its officials; nor why a city should be exempt from liability while a private corporation under the same circumstances should be held responsible for its conduct and made to contribute to the innocent persons it may have damaged." $5,000 awarded.

Jones v. Mount Holly Water Co. (1915) 87 N. J. L. 106: "Water is a necessity of life, and one who undertakes to trade in it and supply customers . . . is bound to use reasonable care to see that whatever is supplied for drink—shall be reasonably pure and wholesome, and that negligently furnishing water which is deleterious to the human body or health will furnish a valid cause of action to a customer injured by the use of the water." "Actual notice or knowledge of the unwholesomeness of the water of the defendant company was not an essential element to be proven in order to establish the defendant's liability; it was sufficient if there was testimony tending to show that the defendant, in the exercise of reasonable care, might have discovered the unwholesomeness and dangerous condition of the water." $750 awarded.

Vennen v. New Dells Lumber Co. 154 N. W. 640: The facts in the case were briefly these: The employing company had a dual water supply in its factory; one source obtained from the city mains, the other from a nearby stream which was badly polluted. The two water distribution systems were connected by a pipe in the boiler room protected by a Globe valve re-inforced by a check valve set against the polluted supply. A num-

ber of employees were in the habit of obtaining drinking water from a faucet in the boiler room which was located so that the polluted river water could reach it. Subsequent to the epidemic of 13 cases of typhoid fever and two deaths, the valves were examined and found leaky. The court held on the demurrer of the defendant that typhoid fever was a compensible accidental injury. Sued for $20,000.

It is significant that in another case—Alex Vander Leest v. John Hoberg Company, Industrial Commission of Wisconsin Workmen's Compensation 10th Annual Report, July 1, 1921 to June 30, 1922, page 59, it was held by the Industrial Commission that compensation was due 19 employees of the company who had contracted typhoid fever by use of water from a polluted well of the company. This case, however, was not carried into the courts. Compensation awarded $2,233.61, medical aid $1,742.94. Total $3,976.45.

Stubbs v. City of Rochester (1919) 226 N. Y. 516: One seeking to hold a city liable for injury by typhoid fever, alleged to have been contracted from defendant's polluted water system, is not bound to eliminate all other possible causes of the disease to establish defendant's liability. That a city's contaminated water supply was the source of typhoid fever in a citizen may be found from the fact that he drank water near the point of contamination, that some sixty other cases developed in that vicinity, that his habits were such as to tend to exclude another probable source, while his physician testified that such contamination was the source of his illness.

Canavan v. City of Mechanicsville, 128 N. E. 882: A private water company or a municipality is not an insuror, nor liable as a guarantor, of the quality of the water it furnishes to its customers by the customary means of pipes and faucets, and can not be held liable for injuries caused by impure water furnished by it, unless it knew or ought to have known of the impurity. Its duty is that of exercising reasonable and commensurate care and diligence in providing an adequate supply of wholesome water at all times.

In the case above cited the court decided that the complaint stated a valid cause of action against the defendant city on account of typhoid fever contracted by plaintiff and his children from drinking impure water.

Roscoe v. City of Everett, 239 Pacific 831: In discussing the case, the court said: "It is sufficient to say that the evidence discloses that on April 11, 1923, a 6-in. main was laid to connect two laterals, and that when the connection was so made it permitted free circulation of water to the city users in the district served, and also better service to the Eclipse Mill Company. At the time this connection was made, there was a by-pass which had existed for a great many years. With the making of the connection there was no longer any need for the by-pass. This by-pass had in it what is known as a gate valve; a valve worked by hand, and which when closed, effectually prevented water from passing through the pipe." . . ."There was evidence that the city never inspected the valve in the by-pass from the date of its installation." . . . "The ease with which the valve could be sealed or by-pass removed and the eminent danger to be apprehended by failure so to do are strong factors in the question of the city's negligence." Award, $60,000.

Procedure for Elimination of Cross Connections, Etc.

To secure data in regard to policies being followed by different State Boards of Health, questionnaires were sent out, 31 replies being received. The questionnaire, with a summarization of the answers, is recorded below:

(1) Are cross connections permitted between public water supplies and polluted factory supplies in your State? If so, under what conditions?

(a) All cross connection prohibited	10
(b) New cross connections prohibited	6
(c) No definite control	7
(d) Permitted with double check valves as protection	8
	31

(2) Are auxiliary intakes whereby a polluted supply may be utilized instead of the regular public supply in case of emergency, permitted? If so, under what condition?

(a) Auxiliary intakes prohibited	12
(b) Permitted when protected as by removing a section of the pipe	12
(c) Permitted on condition State Board of Health notified when used	5

(d) Unanswered 2

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(3) Are by-passes whereby any important part of a water purification plant may be by-passed, thus discharging polluted water into a public water supply, permitted? If so, under what conditions?

(a) By-passes prohibited 17
(b) Permitted with protection as by removing a section of the pipe 10
(c) No definite control 2
(d) Unanswered 2

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(4) What are your rules and regulations or manner of enforcement in each of the above?

(a) Definite regulations regarding cross connections, auxiliary intakes and by-passes 6
(b) Definite regulations regarding cross connections only 3
(c) General control as matter of policy without specific regulations 5
(d) Regulations for by-passes only ... 1
(e) Have power to make but have not enacted regulations 7
(f) No regulations 9

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(5) What trouble have you experienced in the elimination of cross connections, auxiliary intakes and by-passes in connection with the Underwriters' Standards?

(a) No trouble 17
(b) Underwriters have objected to changes 4
(c) No definite information 10

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From questionnaire to States by committees of the Conference, it is noted that in 1921 three states had regulations prohibiting all cross connections with a public water supply and in 1926 eight states had such regulations.

There is evidently a general movement by most states toward the elimination of cross connections. In some instances all cross connections are prohibited, in others new cross connections are prohibited but those existing are permitted to remain, providing they are protected with double check valves, and in some states double check valves are permitted also on new installations. One state, New York, prohibits new cross connections and has set a definite time for the complete elimination of all cross connections.

Your committee believes that it is an accepted opinion that all cross connections, auxiliary intakes and by-passes should ultimately be eliminated. The policy to be followed in bringing this about, however, depends largely upon local conditions and the procedure must be determined by the individual states. This report, therefore, does not attempt to set up a definite policy in securing the elimination of these connections but suggests the following as a possible procedure:

1. Adoption, publication and distribution of regulations by the State Department of Health—

(a) Prohibiting new cross connections,

(b) Requiring the elimination of all existing cross connections as soon as possible.

2. A survey of all cross connections with public water supplies directly by the State Department of Health if possible or otherwise a survey by each municipality with definite reports back to the Department.

3. A definite follow-up program by correspondence and inspections to see that the regulations of the Department are carried out.

SMOOTHER PAVEMENTS FOR INDIANA

The Division of Construction, Road Department, Indiana State Highway Commission, has issued a general letter of instruction, dated June 17, 1926, concerning the smoothness of pavement. The letter is self explanatory and we quote it herewith in full.

"The Bureau of Public Roads is taking roughometer (degree of smoothness) readings of the pavement laid in this and adjoining states. As soon as all of the pavement is logged, charts showing the results of readings on the several sections in this and neighboring states will be prepared and a copy mailed to you.

"The readings taken so far show a considerable variation in pavement smoothness on the different sections. Some of the sections are excellent but the majority are below the average ob-

tained in other states. We do not intend to hold up the other states as a shining example but it is evident that better results can be obtained in this state and at no increase in cost. Better results can not be obtained, however, unless we have the fullest support of the contractor, who through his superintendents and foremen can require first-class workmanship. We are requesting that the contractors give this support and encourage their men to improve this feature of the construction as much as possible.

"The desired results, however, can not be arrived at through the efforts of the contractor alone. The State's forces must hold up their end and make the proper inspection of the work. We will expect this to be done and done in the right way, that is, not by antagonizing everybody on the job, but working in harmony with the men. If the workmen are not capable or do not have the proper attitude, take it up with the contractor or superintendent and have them transferred to some other part of the work that is not so exacting.

"The Project Engineer should also give the pavement his close attention, and should accompany the Inspector frequently when he straightedges the pavement the next morning after it is laid. Observations should be made at this time and such observations will suggest ways for future betterment.

"Bear in mind that a crooked straightedge will not give smooth pavement, neither will it be smooth if it is straightedged when the concrete is too soft. We will expect and look for smoother pavement."

ASSOCIATION OF ASPHALT PAVING TECHNOLOGISTS

The Association of Asphalt Paving Technologists met on Thursday, Jan. 14, 1926, in the Hotel LaSalle, Chicago. The constitution and by-laws were adopted, officers were elected and committees were appointed. Forty members were present.

In January, 1924, a small group met in Chicago informally for the purpose of discussing such an organization. In January, 1925, a considerably larger group met in Chicago and definitely organized. Francis P. Smith, of Dow & Smith, Cons. Engineers, New York City, served as Chairman of the first meeting. Hugh W. Skidmore, of the Chicago Paving Laboratory, Inc., Chicago, Ill., was Chairman of the 1925 meeting, and Charles A. Mullen, of the Milton Hersey Co., Ltd., of Montreal, acted as secretary of both meetings. Roy M. Green, of the Western Laboratories, Lincoln, Neb., was Chairman of the committee which drafted the constitution and by-laws.

The association will collect and distribute technical data pertaining to asphalt paving, encourage and conduct cooperative research work, and will serve as a clearing house of ideas presented by its members. The officers for the present year are:

President, Hugh W. Skidmore, president Chicago Paving Laboratory, Inc., Chicago, Ill.

1st Vice President, Leroy M. Law, Chief Chemist, New Orleans Refining Co., New Orleans, La.

2nd Vice President, W. J. Emmons, Highway Research Specialist, U. S. Bureau of Public Roads, Washington, D. C.

Secretary-Treasurer, Charles A. Mullen, Director, Paving Dept., Milton Hersey Co., Montreal, Que., Canada.

Chairman General Research Committee, Prevost Hubbard, Chemical Engineer, The Asphalt Association, New York, N. Y.

Chairman, Committee on Voids in Aggregates, W. J. Emmons, U. S. Bureau of Public Roads.

Chairman, Committee on Street Operations, W. L. Hemplemann, Engineer, The Texas Co., Asphalt Dept., Chicago, Ill.

LARGEST INSTALLATION OF HIGHWAY LIGHTING UNITS

The 19 mile stretch of highway from South Jacksonville to Neptune, Fla., has been turned into a ribbon of light at night by means of General Electric Novalux highway lighting units. The installation is the largest in the country.

The units are equipped with 400-candlepower lights, and are mounted sufficiently high so that glare is eliminated without cutting down the volume of the illumination.

These lights are turned on every night at the same time the lights in South Jacksonville are turned on, and remain lit until midnight. The county commission is expected later to have the lights on until daybreak.